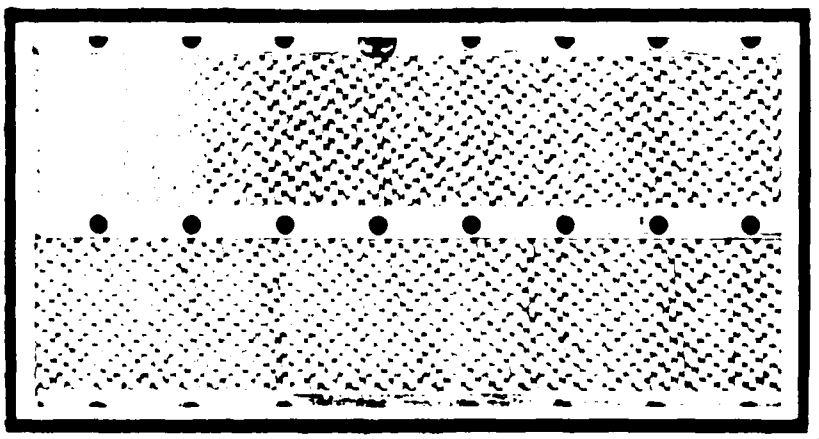

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AFIT/GEM/DEM/87S-1

AN ANALYSIS OF THE MANAGEMENT OF RED HORSE CONSTRUCTION PROJECTS

THESIS

James Andel
Captain, USAF

AFIT/GEM/DEM/87S-1

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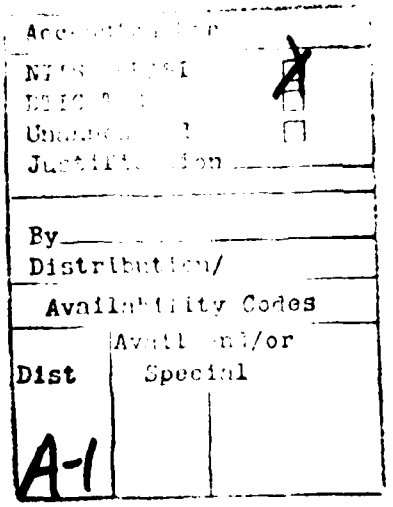

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AN ANALYSIS OF MANAGEMENT OF RED HORSE CONSTRUCTION PROJECTS

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering Management

James Andel, P.E., B.S.

Captain, USAF

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James Andel

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Abstract

The purpose of this study was to examine the management of construction projects undertaken by United Stated Air Force Rapid Engineering Deployable, Heavy Operational Repair Squadron, Engineer (RED HORSE) squadrons. The study was aimed specifically at the roles and responsibilities of construction managers who supervise construction workers and plan day to day construction activities on the job site. The study had three main objectives: (1) To determine what types of construction manager training programs are currently available within the Department of Defense (DOD), (2) To identify the major tasks and responsibilities associated with RED HORSE construction management, and (3) To develop a RED HORSE construction manager's handbook which will be a useful reference for construction managers.

The study found that no DOD training programs are specifically designed to meet the unique needs of RED HORSE units. However, one in resident Navy program, and two Army correspondence courses are especially applicable to RED HORSE construction management.

The study identified twenty-two construction management tasks that are essential to successful RED HORSE construction management. A RED HORSE Construction Manager's Handbook was developed based on these tasks. The handbook was incorporated into separate chapters of the thesis.

AN ANALYSIS OF THE MANAGEMENT OF RED HORSE CONSTRUCTION PROJECTS

I. Introduction

Chapter Overview

This chapter provides general background information on the problems associated with the management of RED HORSE construction projects. This chapter outlines the specific problem, justification, scope, and limitations of this study. Additional information on the organization and manning of RED HORSE squadrons is provided in Appendix A.

General Issue

United States Air Force Rapid Engineering Deployable, Heavy Operational Repair Squadron, Engineer (RED HORSE) squadrons are 400-man combat engineer units which provide the Air Force with a wartime heavy construction and repair capability. During peacetime, proficiency in construction skills is maintained by undertaking various construction projects throughout the world. Typical RED HORSE construction projects include such things as building runways, power plants, maintenance facilities, and power distribution systems. Benefits to the Air Force include:

1. Accomplishment of these projects enables the units to maintain proficiency in their wartime mission.

2. Emergency and high priority projects can be undertaken on short notice.

3. Projects are completed at a significant cost savings as compared to having the work done by contract (8:Sec 1,8).

Specific Problem

Except for extremely large or especially complicated projects, RED HORSE construction managers are typically noncommissioned officers who are craftsmen skilled in their particular trade but have only a limited knowledge of overall project management. Construction managers are responsible for the management of materials and supplies, personnel, project funds, construction standards, project schedules, and the supervision of craftsmen from several different career fields.

AFR 93-9, Civil Engineering RED HORSE Squadrons, "outlines policy and procedures for operating and managing RED HORSE squadrons," including training requirements (4:2). AFR 93-9 requires that at least a specified minimum number of personnel be trained in a variety of areas including specialized construction tasks; however, no construction management training is required (4:40).

Justification

The subject of RED HORSE construction management was submitted to AFIT/LS as a thesis research topic by the Chief of Operations of an active duty RED HORSE squadron. The two major concerns expressed by the requester were:

1. RED HORSE construction managers manage a variety of resources including materials, equipment, personnel, and money.

2. RED HORSE construction managers supervise craftsmen from several different career fields outside of their own.

Presently, the requester's unit provides each construction manager with a handbook of information concerning the management of RED HORSE projects. This handbook is very similar to construction management handbooks used by the other RED HORSE squadrons. The requester indirectly indicated that the handbooks presently available fail to adequately prepare a craftsman to assume the duties and responsibilities associated with RED HORSE project management.

Objectives

The objectives of this study were:

1. To determine what types of construction manager training programs are currently available within the Department of Defense (DOD).

The purpose of this objective was to identify existing training programs within the Department of Defense that may be available for the training of RED HORSE construction Managers.

2. To identify the major tasks, skills, and responsibilities associated with RED HORSE construction management.

The purpose of this objective was to identify the basic duties and responsibilities inherent in RED HORSE construction management. Once these tasks, skills, and

responsibilities are identified, the information can be used as the basis for developing a construction manager's training program and/or a construction manager's handbook specifically tailored to the needs of RED HORSE units.

3. To develop a construction manager's handbook that will be of use to RED HORSE construction managers and other military personnel engaged in similar construction activities.

The purpose of this objective was to develop a handbook of information specifically applicable to the management of RED HORSE construction projects. The handbook is intended to be a practical reference for construction managers for all phases of a project, from predeployment planning through completion of construction.

Assumptions

This study was conducted under the following assumptions:

1. Because of budget, time, and manpower limitations, it is not possible for all RED HORSE construction managers to attend formal construction management training programs.

2. A construction management handbook is the best means for providing construction managers with useful reference material concerning construction project management.

Scope and Limitations

The main emphasis of this study was directed toward preparing craftsmen to be construction managers. Numerous professional and continuing education programs are available to engineers desiring to increase their knowledge of project

management (12:7-8; 1:2). There is a need to make this same type of information available to craftsmen who are moving into management positions (23:25-26).

This study pertains to information that will be of use to construction managers in both the planning and construction phases of RED HORSE projects. The combat role of RED HORSE was not addressed.

Definitions

Construction Manager. A person "who takes charge of the onsite building process (23:25)." RED HORSE construction managers are usually noncommissioned officers. According to AFR 93-9, the management responsibilities of construction managers include:

1. Developing a project schedule to be used in scheduling construction effort and monitoring project progress.
2. Coordinating the allocation of RED HORSE equipment and manpower with the operations center.
3. Arranging host base support including billeting, messing, and work and storage areas through the host base civil engineer.
4. Maintaining project records.
5. Keeping project cost accounting records (4:33).

Project Manager. A person "who runs an entire job from inception to completion (23:25)." RED HORSE project managers are usually engineering officers. According to AFR 93-9, a project manager is responsible for:

1. Designing and coordinating projects.

2. Serving as primary point of contact for all squadron activities relating to the project.

3. Maintaining the project folder.

4. Reviewing design documents and supervises project if designed by other than RED HORSE.

5. Chairing design conferences.

6. Coordinating design with base representatives.

7. Insuring that the current working estimate does not exceed the project funded cost (4:32).

RED HORSE Squadron. AFM 93-9 defines RED HORSE squadrons as:

> Headquarters Air Force controlled squadrons established to provide the Air Force with a highly mobile, self-sufficient, rapidly deployable civil engineering heavy construction and repair capability (4:6).

Project Manager and Construction Manager Roles

Project manager and construction manager roles can best be examined and described by looking at an example. A large RED HORSE construction program recently undertaken by one RED HORSE squadron included a variety of projects typical of the size and type RED HORSE construction managers can be expected to manage. Details of this construction program are provided in Table 1.

Management of these projects consisted of one engineering officer assigned as the project manager, and eight noncommissioned officers assigned as construction managers. This is a typical management arrangement, one project manager is usually responsible for several projects

Table 1.

Typical RED HORSE Construction Program

	PROJECT	COST
1.	Repair and overlay of a 10,000 foot runway and 10,000 foot taxiway.	$3,500,000
2.	Runway shoulder stabilization.	$ 400,000
3.	Construction of a 1760 KW power plant.	$1,500,000
4.	Installation of an underground high voltage power distribution system.	$ 500,000
5.	Repair and addition to potable water storage facilities.	$ 100,000
6.	Repair and upgrade of sewage disposal facilities.	$ 80,000
7.	Renovation of a mess hall.	$ 150,000
8.	Construction of a cold storage shelter.	$ 20,000

simultaneously, while a construction manager is normally assigned to only one project at a time. In addition, usually a project manager's projects are located at various bases throughout a major command, thus limiting the time the project manager can devote to any single project. This often leaves the construction manager as the only full time manager actually on the job site.

Chapter Summary

This chapter identified and discussed some of the problems associated with RED HORSE construction management. Next, current literature is examined to obtain background information on construction management in general.

II. Literature Review

Chapter Overview

This chapter reviews current literature dealing with the need for construction manager training, reviews the tasks that construction managers are normally expected to perform, and discusses the elements of effective training programs.

Need for Training

There is no shortage of current literature dealing with the subject of project management or construction management training programs; however, the emphasis is on professional level training for engineers. Currently numerous programs are available for engineers, ranging from professional short courses to bachelor and masters degree programs in construction management (19:582-584). However, little current literature deals directly with the training of craftsmen who will be moving into first line management positions.

Studies conducted by the Business Roundtable as part of their Construction Industry Cost Effectiveness Project concluded that "Many project and construction managers have inadequate ability for planning, managing and supervising field construction operations (23:81)." Concerning the inadequate training of supervisors, the project concluded that "The missing element is not their technical skill . . . but rather too little schooling in such supervisory

techniques as communicating with workers and planning their work (23:59)."

Construction Management Tasks

Construction managers are responsible for the onsite supervision of construction projects, and are consequently required to perform a variety of tasks.

Paragraph 6-12b, of AFR 93-9 requires RED HORSE construction managers to:

1. Develop project schedules
2. Coordinate the allocation of manpower and equipment
3. Arrange for billeting, messing, and storage space.
4. Maintain project records.
5. Maintain cost accounting records (4:33).

In addition to the tasks listed in AFR 93-9, construction managers normally are expected to be familiar with a variety of other tasks associated with the management of a construction projects. A study conducted by The Business Roundtable as part of their Construction Industry Cost Effectiveness Project identified twelve training topics common to most construction projects:

1. Planning.
2. Scheduling.
3. Safety.
4. Material control.
5. Leadership.
6. Motivation.

7. Organizing work.

8. Directing and coordination work.

9. Quality control.

10. Human relations.

11. Problem solving and methods improvement.

12. Effective communications (22:10-11).

This list compares favorably with a study conducted by Abraham Warszawski. In this study, Warszawski identifies the major tasks of construction management as:

1. Estimating.

2. Selection of construction methods.

3. Site planning.

4. Organization of construction teams.

5. Subcontracting.

6. Scheduling.

7. Processing of technical information.

8. Procurement of materials and services.

9. Contract administration.

10. Cost and schedule control.

11. Quality control.

12. Coordinating and directing of works.

13. Personnel management (26:299-300).

Although this study dealt with the education of construction managers in graduate and undergraduate engineering programs, the list of tasks is an excellent description of the tasks that either a project manager or a

construction manager might perform, depending on the specific nature of the project.

Training Programs

According to The Business Roundtable, some common complaints that contractors have about existing training programs are:

1. Most of the programs are too general.
2. Too many are too general in nature - or are strictly motivation oriented.
3. Many training techniques . . . do not target situations as they occur on the construction site.
4. Available programs need to be tailored to meet specific job site objectives.
5. In-house programs are desperately needed; programs available through marketing do not provide adequate solutions to specific needs (22:4-5).

As a result, The Business Roundtable states that to be effective, training programs "must be specific and tailored to the needs of both the project and the individuals involved in it, as determined by prior analysis (22:10)."

Chapter Summary

Problems associated with the management of RED HORSE construction projects are nearly identical to the management problems in the civilian construction industry. The current emphasis in the civilian construction industry is towards more training for construction managers. The next chapter, Methodology, discusses the methods of research pursued to accomplish the stated objectives of this study.

III. Methodology

Chapter Overview

This chapter describes in detail, the steps taken to accomplish the stated objectives of this study.

Research Steps for Objective One

The first objective of this study was to determine what types of construction manager training programs are currently available within the Department of Defense. The purpose of this was to identify programs that may be available for training RED HORSE construction managers.

The first step taken to meet this objective was to identify DOD agencies which might be involved in either military construction or engineer training. Several agencies were considered possible sources of information for this objective:

1. USAF Technical Training Center, Sheppard AFB, Texas.

The USAF Technical Training Center was selected because it provides both basic and advanced technical training to military personnel assigned to the civil engineering career field (6).

2. U.S. Army Engineer School, Fort Belvoir, Virginia.

The U.S. Army Engineer School was selected because it offers several engineering and construction related correspondence courses through the U.S. Army Institute for Professional Development (10).

3. U.S. Army Corps of Engineers, Huntsville Division, Huntsville , Alabama.

Although the Corps of Engineers is not normally involved with projects accomplished by combat engineers, the Huntsville Training Division manages the Corps of Engineer's short course program which includes courses in construction management (11).

4. U.S. Naval Construction Battalion, Gulfport, Mississippi.

U.S. Naval Construction Battalions, or Seabees, provide combat engineering support to the U.S. Navy during wartime, a mission which is very similar to the mission of RED HORSE units (14:Sec 1,7). Seabee training is conducted at Gulfport, Mississippi and Port Hueneme, California (14).

Data Collection. Data was collected by researching course descriptions of courses offered by the above agencies. Course descriptions were obtained from lists of course offerings published by each school. Additional information was obtained by conducting telephone interviews with training technicians from each agency.

Telephone interviews are a useful and widely accepted method of collecting data. Some of the advantages of using telephone interviews are low cost, calls to various locations can be made from a single location, and telephone interviews are more economical than personal interviews if sources of information are located in distant locations.

Also, questions and answers can be expanded upon and pursued in further depth if necessary (16:305-306).

Some disadvantages of telephone interviews are time limitations on the length of the interviews, and the inability to use illustrations (16:306). Practical time limitations for telephone interviews are about ten to twenty minutes (16:306). For the purposes of this objective, neither of these disadvantages were significant in this situation.

After researching the course catalogs, the next step was to conduct the interviews in order to determine if any additional courses were available. One training technician at each agency was asked the following question:

Does your organization offer any training courses dealing with the management of construction projects accomplished by troop labor or combat engineers that are not listed in the current school catalog?

If the response to this question was yes, the following information was requested:

A. Name of course or program.

B. Length of course.

C. Location of course.

D. Prerequisites.

E. Subjects covered.

Any additional data obtained from the telephone interviews was used to supplement the information obtained from the school catalogs.

Research Steps for Objective Two

The second objective of this study was to identify the major tasks, skills, and responsibilities associated with RED HORSE construction management.

The first step was to identify tasks assigned to RED HORSE construction managers by Air Force Regulation. Paragraph 6-12b, of AFR 93-9 states that RED Horse construction managers will:

1. Develop project schedules.
2. Coordinate allocation of manpower and equipment.
3. Arrange for billeting, messing, and storage areas.
4. Maintain project records.
5. Maintain cost accounting records (4-33).

The next step was to identify other construction management tasks that RED HORSE construction managers could reasonably be expected to perform. This was accomplished by comparing Warszawski's list of construction management tasks (26:299-300) with the supervisory training topics identified by the Business Roundtable (22:11). A comparison of the two lists is shown in Table 2. The topics in the two lists differ somewhat because Warszawski's study dealt with the training of project managers, while the Business Roundtable report was directed at the training of construction managers; however, the roles of project and construction managers overlap somewhat.

Table 2.

Construction Management Tasks

	TOPIC	WARSZAWSKI	ROUNDTABLE
a.	Estimating	X	-
b.	Construction Methods	X	-
c.	Site Planning	X	-
d.	Organization of Construction Team	X	-
e.	Subcontracting	X	-
f.	Scheduling	X	X
g.	Processing of Technical Information	X	-
h.	Procurement of Materials	X	-
i.	Contract Administration	X	-
j.	Cost and Schedule Control	X	-
k.	Quality Control	X	X
l.	Coordinating and Directing Work	X	X
m.	Personnel Management	X	-
n.	Planning	-	X
o.	Safety	-	X
p.	Material Control	-	X
q.	Leadership	-	X
r.	Motivation	-	X
s.	Organizing Work	-	X
t.	Human Relations	-	X
u.	Problem Solving	-	X
v.	Effective Communications	-	X

Comparing lists, scheduling, quality control, and coordinating and directing work appeared on both lists. Several other items could be considered equivalent. No attempt was made to consolidate the two lists at this point. This insured that as many topics as possible would be considered while working toward the stated objective.

The next step was to determine which topics on the combined list were most representative of the tasks associated with the management of RED HORSE construction projects.

Data Collection. Data was collected by conducting personal interviews with personnel who have had experience with managing RED HORSE construction projects.

Personal interviews are "an excellent data collection technique (16:293)." Some advantages of personal interviews are the depth, quality, and volume of information that can be obtained. The major disadvantage of personal interviews is the potentially high cost, especially if the respondents are not centrally located, or are difficult to reach (16:294).

Because of the depth and quality of information that can be obtained with personal interviews, this method was selected as an appropriate method of data collection for the this objective. The disadvantages associated with personal interviews were overcome by limiting the interviews to students currently assigned to the Air Force Institute of Technology.

Personal interviews were conducted with three students who were previously assigned to RED HORSE squadrons and have managed RED HORSE projects. Personnel with such experience are valuable sources of information concerning the identification of tasks associated with the management of RED HORSE projects. Taking this approach was intended to avoid the shortcomings of many construction management training programs which are considered "too general" and do not "fit what happens on job sites (23:59)."

The general type of questions asked during each interview were:

1. Based on your experience, what are the most important topics that should be covered in a RED HORSE construction manager's training program?

2. What types of information would be most useful to include in a RED HORSE construction management handbook?

During each personal interview, each respondent was also asked to review the construction management tasks listed in AFR 93-9, and the combined Warszawski - Business Roundtable list. Each respondent was then asked to identify the tasks that would be most appropriate to address in a RED HORSE construction manager's training program an/or handbook.

Research Steps for Objective Three

The third objective of this study was to develop a RED HORSE construction manager's handbook that will be of practical use on construction sites.

Information contained in the handbook was intended to meet three basic needs:

1. Provide RED HORSE construction managers with a source of useful reference material.
2. Cover appropriate topics in enough detail to provide personnel who have not had the opportunity to attend a formal training program, with at least a basic working knowledge of the duties and responsibilities of a RED HORSE construction manager.
3. Be adoptable as a basic text which could be used in a RED HORSE training program.

The selection of subject matter to be included in the handbook was based on two factors. First, AFR 93-9 specifically identifies several tasks that must be performed by RED HORSE construction managers. Since these tasks are required by regulation, their inclusion in the handbook is essential. Several other tasks that construction managers could reasonably be expected to perform on RED HORSE projects were identified by experienced RED HORSE construction managers during the accomplishment of objective two.

Information included under each specific topic covered in the handbook was obtained from a variety of sources, including military technical manuals, trade publications, and personal experiences.

Chapter Summary

This chapter described the methodology followed to accomplish the three stated objectives. The next chapter, titled Results, discusses the outcome of this research.

IV. Results

Chapter Overview

This chapter discusses the availability of existing construction manager training programs within the Department of Defense, identifies tasks and responsibilities associated with RED HORSE construction management, and outlines the organization and content of a proposed construction manager's handbook.

Results of Research Objective One

The first objective of this study was to determine what types of construction manager training programs currently exist within the Department of Defense. Several training courses covering various aspects of construction management are currently available, however none of the courses are designed specifically for the training of RED HORSE construction managers.

U.S. Air Force Course. Only one formal Air Force course was found that dealt with construction supervision. Details of the course are provided in Table 3.

Table 3.

U.S. Air Force Supervisor Course

Course Title: Base Civil Engineer Supervisor.
Course Number J3AZR55000 003.
Location: Sheppard AFB, Texas.
Length: 3 Weeks
Course Content: Personnel management; leadership; planning; scheduling; base civil engineer topics (6:Sec 3,150).

This course is only marginally applicable to the training of RED HORSE construction managers. The course is designed specifically to prepare supervisors for management functions related to a base civil engineering maintenance and repair function, which involves supervising small jobs in contrast to large RED HORSE construction projects.

U.S. Army Courses. Several correspondence courses prepared by the U.S. Army Engineer School are available through The Army Institute for Professional Development, School Code 051, US Army Training Support Center, Newport News, Virginia 23628. These courses cover a variety of civil engineering topics and career fields. Army correspondence courses that are particularly applicable to RED HORSE construction management are listed in Table 4.

Table 4.

U.S. Army Correspondence Courses

Course Title: Construction Planning.
Course Number: EN0067.
Course Length: 12 study hours.
Course Content: Theater of operations construction principles; construction management functions; critical path method; construction supervision; estimating techniques used for earthmoving, paving, concrete work, carpentry, masonry, roofing, electrical work, metal work, and equipment installation (10:1).

Course Title: Construction Management.
Course Number: EN0375.
Course Length: 19 study hours.
Course Content: Application of management principles to construction management; use and application of the critical path method; estimating manpower, equipment, and materials; scheduling construction activities; site planning; effective construction supervision; control of job progress (9:1).

Both the Construction Planning and the Construction Management courses are excellent courses for supervisors desiring to increase their job knowledge in the areas of planning, scheduling, estimating, and supervising construction projects. These courses are excellent because in addition to covering the basics of construction planning and management, they stress practical applications of the material covered. Students in both courses are provided with copies of Army Technical Manual TM 5-333, Construction Management, which is an extremely useful reference book.

Other correspondence courses covering such topics as blueprint reading, surveying, electricity, air conditioning, carpentry, pavements, equipment operations, demolitions, weapons, and combat engineering are also available through The U.S. Army Institute for Professional Development.

U.S. Army Corps of Engineers Courses. The U.S. Army Corps of Engineers Huntsville Training Division offers a variety of construction training courses, however, most are directed toward contract management rather than management of troop labor construction projects and would not be particularly beneficial to RED HORSE construction managers (11:Sec 2,4, 152).

U.S. Navy Courses. The U.S. Navy Seabees offer basic and advanced courses for builders, electricians, mechanics, engineering aids, equipment operators, steel workers, and utilitiesmen (plumbing and air conditioning). The purpose

of the advanced courses is to provide noncommissioned officers with the management and technical skills necessary to qualify as a team leader on construction projects (14:Sec 3,4).

After reaching noncommissioned officer status, craftsmen are eligible to attend the advanced course which qualifies them as a trade crew leader on construction projects. After completion of the course, Navy personnel are assigned as team leaders under the guidance of more experienced noncommissioned officers, and are given more responsibility as their skill and experience increase (17).

Navy courses applicable to the training of RED HORSE construction managers are listed in Table 5.

Table 5.

U.S. Navy Construction Management Courses

Course Title: Advanced Builder.
Course Number: A-710-0011
Location: Port Hueneme, California and Gulfport, Mississippi.
Length: 82 Days.
Course Content: Mathematics; placing, finishing and testing concrete; masonry construction; foundation construction; wall and roof framing; erection of advanced base structures; job planning; estimating; material take off; construction safety; techniques of foremanship (14:Sec 3,4)

Course Title: European Construction Materials and Techniques.
Course Number: 192.1S.
Location: Port Hueneme, California and Gulfport, Mississippi.
Length: 3 Weeks.
Course Content: European construction terminology; drawings; specifications; construction materials and equipment (14:Sec 3,33).

The management topics covered in the Advanced Builder course are typical of the management topics covered in the other advanced courses. All of the Navy advanced courses would be appropriate for providing management training for RED HORSE noncommissioned officers.

The European Construction Materials course would be a worthwhile course for RED HORSE construction managers and craftsmen assigned to European based RED HORSE units.

Results of Research Objective Two

The second objective of this study was to identify the major tasks and responsibilities associated with RED HORSE construction management.

Personal interviews were conducted with three individuals with prior RED HORSE construction management experience (3; 20; 27). During each interview, the respondent was asked to review the list of construction management tasks prepared by Warszawski and The Business Roundtable and indicate those topics that they felt were applicable to the management of RED HORSE projects. Each respondent was also asked to suggest additional topics to add to the list.

The number of respondents who felt that a particular task was relevant to the management of RED HORSE projects is indicated in Table 6, which is a comparison of construction management tasks identified by Warszawski, The Business Roundtable, and experienced RED HORSE construction managers.

Table 6.

Potential RED HORSE Construction Management Tasks

Key to abbreviations: WAR. = Warszawski

TBR = The Business Roundtable

RH = RED HORSE Respondents

	TASK	WAR.	TBR	RH
1.	Estimating.	X	-	1
2.	Construction Methods	X	-	3
3.	Site Planning	X	-	2
4.	Organization of Construction Team	X	-	3
5.	Subcontracting	X	-	0
6.	Scheduling	X	X	3
7.	Processing of Technical Information	X	-	0
8.	Procurement of Materials	X	-	2
9.	Contract Administration	X	-	0
10.	Cost and Schedule Control	X	-	0
11.	Quality Control.	X	X	3
12.	Coordinating and Directing Work	X	X	3
13.	Personnel Management	X	-	3
14.	Planning	-	X	2
15.	Safety	-	X	2
16.	Material Control	-	X	2
17.	Leadership	-	X	3
18.	Motivation	-	X	2
19.	Organizing Work	-	X	3
20.	Human Relations	-	X	2

Table 6 (continued).

	TASK	WAR	TBR	RH
21.	Problem Solving	-	X	2
22.	Effective Communications	-	X	3
23.	Public Relations.	-	-	2
24.	Host Base Support	-	-	2
25.	Project Funding	-	-	1

Identification of Tasks

In general, experienced RED HORSE project managers felt that most of the topics contained in the combined Warszawski/Roundtable list were applicable to RED HORSE construction management. The only exceptions were subcontracting, processing of technical information, contract administration, and cost and schedule control.

After considering the information listed in Table 6 and comments received during the personal interviews, it was decided that twenty-two of the twenty-five potential topics were important RED HORSE construction management tasks.

The following tasks were identified as being the most applicable to RED HORSE construction management:

1. Estimating.
2. Construction methods.
3. Site planning.
4. Organization of construction team.
5. Scheduling.
6. Procurement of materials.

7. Cost and schedule control.
8. Quality control.
9. Coordinating and directing work.
10. Personnel management.
11. Planning.
12. Safety.
13. Material control.
14. Leadership.
15. Motivation.
16. Organizing work.
17. Human relations.
18. Problem solving.
19. Effective communications.
20. Public relations.
21. Host base support.
22. Project funding.

Cost and schedule control was determined to be appropriate even though it was not identified as important by the experienced RED HORSE personnel interviewed. The reason for selecting cost and schedule control was that maintaining cost accounting records is one of the five basic construction management duties required by AFR 93-9.

In addition to the tasks listed in the Warszawski/Roundtable list, public relations, host base support, and project funding were determined to be appropriate based on the suggestions of experienced RED HORSE construction managers.

The following topics were considered as only marginally applicable to the management of RED HORSE projects:

1. Subcontracting.
2. Processing of technical information.
3. Contract administration.

The reason for not selecting subcontracting and contract administration is that even though some specialized work my be accomplished by contract on some RED HORSE projects, the contracting function is normally a responsibility of the host base civil engineering squadron. Processing of technical information was not selected because this is usually a function of a design or project engineer rather than a RED HORSE construction manager.

Next it is necessary to determine if the topics selected will adequately support the five construction management tasks listed in AFR 93-9 which requires RED HORSE project managers to:

1. Develop project schedules.
2. Coordinate allocation of manpower and equipment.
3. Arrange for billeting, messing, and storage areas.
4. Maintain project records.
5. Maintain cost accounting records (4:33).

In order to develop a project schedule, a manager must be knowledgeable in the following areas:

- Estimating
- Construction Methods
- Organization of the Construction Team

- Scheduling
- Planning

To effectively coordinate the allocation of manpower, equipment, and materials, a construction manager must be knowledgeable in the following areas:

- Construction Methods
- Organization of the Construction Team
- Scheduling
- Procurement of Materials
- Coordinating and Directing Work
- Personnel Management
- Planning
- Organizing Work
- Material Control
- Problem Solving
- Effective Communications

Arranging for billeting, messing, and storage areas, requires knowledge of:

- Site Planning
- Personnel Management
- Public Relations
- Host Base Support

In order to properly maintain project records, a construction manager must be familiar with:

- Cost and Schedule Control

In order to maintain project cost accounting records, a construction manager must be knowledgeable of:

- Cost and Schedule Control
- Project Funding

In addition to the the above tasks, construction managers also have other duties and responsibilities inherent with their position as noncommissioned officers such as:

- Leadership
- Motivation
- Human Relations
- Safety
- Quality Control

The twenty-two construction management tasks identified in this section represent a basic list of tasks and responsibilities inherent in RED HORSE construction management. This information can be used to develop a RED HORSE construction manager's handbook specifically tailored to the needs of RED HORSE construction managers.

Results of Research Objective Three

The third objective of this study was to develop a construction manager's handbook that will be of practical use to RED HORSE construction managers. The three stated purposes of the handbook are as follows:

1. Provide RED HORSE construction managers with a source of useful reference material.
2. Cover appropriate topics in enough detail to provide personnel who have not had the opportunity to attend a formal training program, with at least a basic working knowledge of the duties and responsibilities of a RED HORSE construction manager.

3. Be adoptable as a basic text which could be used in a RED HORSE construction manager training program.

The construction management handbook was developed around the twenty-two topics identified by research objective two. The handbook is divided into twelve sections and comprises Chapters V through XVI of this thesis. These chapters can be separated from the research portions of the thesis in order to provide a usable handbook.

The RED HORSE construction manager's handbook is organized as follows:

Chapter V - Introduction. The introduction contains basic definitions and a table of contents.

Chapter VI - Construction Safety. Common safety violations frequently observed on construction sites are discussed in this section.

Chapter VII - Project Familiarization. This chapter discusses project records, funding, and initial estimates.

Chapter VIII - Project Meetings. This section deals with effective communications between the construction manager and other personnel that will be supporting the project.

Chapter IX - Preconstruction Site Visit. Topics included in this section include coordination of host base support and site planning.

Chapter X - Project Planning. Project planning covers organizing work, estimating, initial manpower, equipment, and material requirements, and Precedence Diagrams.

Chapter XI - Scheduling. This section covers developing a project schedule, scheduling of manpower and equipment, and use of the Critical Path Method.

Chapter XII - Organizing the Construction Team. This section explains how crews and equipment are selected for a project, and discusses the coordinating activities necessary for a deployment.

Chapter XIII - Funds Management. The funds management section covers record keeping, management of project funds, and cost reporting.

Chapter XIV - Material Control. This section covers effective control of materials on the job site.

Chapter XV - Construction Methods and Quality Control. This section pertains to work performed on the job site, construction techniques, and construction quality control.

Chapter XVI - Personnel Management. This section covers the basics of leadership, motivation, and human relations.

Information contained in the handbook was obtained from a variety of sources, including military manuals, commercial publications, and personal experiences.

Chapter Summary

This chapter discussed results of research conducted to accomplish the three objectives of this study. The construction manager's handbook developed under research objective three comprises Chapters V through XVI of this thesis.

V. RED HORSE Construction Manager's Handbook

Introduction

Chapters V through XVI of this thesis, Appendices B and C, and the Bibliography constitute the RED HORSE construction manager's handbook developed to fulfill objective three of this study.

The purpose of this handbook is to provide RED HORSE construction managers with a basic knowledge of the principles involved with managing construction projects. An understanding of these principles and the ability to apply them are essential to successful construction management.

The handbook is divided into twelve sections covering the planning and execution phases of a RED HORSE construction project. The material is presented in a logical sequence; however users should be aware that every project is unique, and the sequence of steps taken during the planning and execution phases of a project can vary significantly depending on the circumstances. This is especially true for military construction units which are frequently tasked to undertake projects on short notice with little or no time available for detailed planning.

This handbook covers the basics of RED HORSE construction management in general terms only. The handbook should be supplemented or modified by each using unit to fit their needs. Possible supplements to this handbook could include specific unit policies concerning report formats,

discipline, checklists, and other information concerning local policies and procedures.

Table 7 is a Table of Contents for the handbook, and Table 8 is a List of Figures used to illustrate points discussed in the handbook.

Definitions

An understanding of the following terms is necessary to understand the information presented in this handbook:

Construction Manager. A construction manager is the person "who takes charge of the onsite building process (23:25)." Construction managers are responsible for the planning and supervision of construction activities. Except for very large or complex projects, RED HORSE construction managers are usually noncommissioned officers.

Project Manager. A project manager is a person "who runs an entire job from inception to completion (23:25)." This definition refers to an individual whose primary duties normally involve being the primary point of contact responsible for coordinating project requirements. Project managers are not usually involved with the daily supervision of construction activities. Depending on the size and complexity of the project, a RED HORSE project manager could be an engineering officer, a shop superintendent, or any other designated individual.

Table 7.

Handbook Table of Contents

Table 8.

Handbook List of Figures

VI. Construction Safety

Introduction

Construction managers are responsible for maintaining a safe work environment on the job site. This section will help a construction manager identify some of the most common safety hazards associated with construction work.

Safety on the Job Site.

Maintaining a safe job site takes a lot of effort on the part of a construction manager. Safety standards have to be monitored on a continuous basis, otherwise, safety on the the job site will begin to deteriorate. Some of the most common safety hazards found on construction projects are:

1. Improperly shored or sloped excavations.
2. Ungrounded or unguarded portable electric tools.
3. Improperly maintained and substandard scaffolding.
4. Absence of or inadequate guard rails at floor, wall and roof openings.
5. Absence of or inadequate barricades for site perimeter.
6. Improper or unsecured ladders.
7. Improper handling and storing of flammable liquids and compressed gas cylinders
8. Poor general housekeeping.
9. Lack of qualified first-aid attendant at site.
10. Failure to wear personal protective equipment.
11. Failure to backfill holes and trenches promptly.
12. Unsafe crane operation (2:352-353).

Most of the above items are self explanatory; however, some additional comments are appropriate:

The walls of all trenches over five feet deep must be properly shored or sloped to prevent the walls from caving in. You should discuss shoring requirements with an engineer to insure that the shoring technique used will be adequate for the soil conditions encountered. As an alternative to shoring, the sides of trench walls above the five foot level can be sloped to prevent the walls from caving in. The amount of slope required depends on the stability of the soil encountered. A slope of 1:1 is recommended for average soil conditions (25:22853).

All open excavations should be adequately roped off or barricaded to reduce the hazard to personnel and vehicles operating near the excavation. Another general rule is that all excavations should be inspected at least daily, and after every rain storm, to insure that the trench walls are still in safe condition.

You should check with the host base fire department concerning proper storage of any flammable liquids you will be using. Compressed gas cylinders, whether empty or full, should be stored in an upright position, and be firmly secured.

Failure to wear proper protective equipment is a very common safety violation. One frequent violation is failure to wear proper eye protection. Two operations that you will frequently observe this violation on are when material is

being cut with a rescue saw, and when concrete joints are being cut with a concrete saw.

Another common piece of protective equipment commonly overlooked is rubber boots for personnel who will be placing concrete. When placing concrete for large slabs, it is necessary for workers to be standing and working in the freshly placed concrete. Many workers tend to wear leather combat boots rather than rubber boots when assigned to this task. Prolonged exposure to wet concrete can cause serious skin irritation, especially if the worker has an open cut on his foot. You should always have a supply of rubber boots available for concrete placement operations.

One additional common safety violation not mentioned on the above list is the use of personal cassette players on the job site. Listening to music through a personal headset significantly reduces a worker's awareness of activities that are taking place around him. It could also cause the worker not to hear a safety warning. You should make it clear to the entire crew that personal cassette players will not be allowed on the project. Usually, most workers are receptive to this once they understand the reasons for your decision; however, you should be aware that some workers may try to continue to use these devices by running the earphone wire under their shirt, and concealing the earphones within their ear protectors. Close observation will always detect the unconcealed wire running between the neck of the shirt and the ear protectors. Violators should be disciplined.

Job Site Safety Program

As a construction manager, you are responsible for the health and safety of your crew. You should establish a safety program on the job site to insure that your project site is as safe as possible. A safety program built around your true concern for the safety of the crew is usually more effective than a program built strictly around the enforcement of safety regulations.

During the day when you are checking the work in progress, you should watch for unsafe work practices. Any safety violations you observe should be corrected on the spot.

Mandatory safety briefings should be held weekly; however, these weekly metings should be supplemented occasionally with other pertinent information. For example, during morning formation, it would be appropriate to discuss safety requirements associated with a new phase of work that will begin that day, or to remind the workers of safety violations that were observed frequently during the past few days. Workers are usually more receptive to this type of reminder than when safety is discussed only during routine weekly briefings.

VII. Project Familiarization

Introduction

Immediately after you are notified that you have been selected as a construction manager, you should familiarize yourself with the details of your project. This section provides some suggestions that will help you gain an initial understanding of your project.

Initial Meeting with the Project Manager

The first step in the project familiarization process is to discuss the project with the project manager. During this initial meeting, the project manager will provide you with some basic information about the project such as location, scope of work, estimated starting date, projected crew size, funding status, special equipment or material requirements, and any special problems that may be encountered during construction. A set of project drawings should be reviewed, with the project manager pointing out key elements of the project.

Project Records

After your initial meeting with the project manager, you should review the contents of the project folder. Air Force Regulation 93-9 requires the project manager to maintain the following records:

A. Approved project programming documents.

B. Work directive and change orders.

C. Project drawings.

D. Specifications.

E. Man-hour, equipment, and cost estimates.

F. Construction conference minutes.

G. Results of lab testing.

H. Diary of construction effort including status of progress, unique design and construction problems encountered, and results of progress inspections.

I. Related project correspondence (4:33).

Normally, these records are maintained in the project folder. Depending on the current status of the project, the project folder will be available from either the engineering section or the operations section. The project manager will be able to direct you to the proper location.

A thorough review of the project folder is necessary in order to become familiar with all aspects of your project. If any of the above documentation is not contained in the project folder, check with the project manager.

A review of a project folder can be quite time consuming, so plan on spending several hours or more reviewing the folder and drawings. Certain documents in the folder require your particular attention, some of the most important things to look for are described in the following paragraphs.

Funding Documents. When reviewing the funding documents, the first document you should look for is the approved DD Form 1391, Military Construction Data. This is the document used to obtain funding and approval to

undertake the project. The DD Form 1391 contains a brief description of the work involved, a summary of the estimated cost, and justification for the project.

After locating the DD Form 1391, it is very important to insure that you are reviewing a copy of the Major Air Command (MAJCOM) approved form. Approved documents are readily identified because MAJCOM approval will be indicated on the face of the document. If the folder does not contain a copy of the MAJCOM approved DD Form 1391, contact the project manager immediately. The reason for working only with approved documents is that the approved scope of work may be different than the scope of work originally requested.

A good place to begin reviewing the DD Form 1391 is in block 10. This block contains a brief description of the approved scope of work. The project description is usually very brief and describes the project only in very general terms; however, it is very important to your understanding of the project.

Next look at block 9 of the DD Form 1391. This section contains a summary of the project cost estimate. The key figure to obtain from this section is the estimate for the total funded cost of the project. This figure is listed in section 9, and again in block 8 of the DD Form 1391.

The next document to locate is the funding authorization. Funding authorizations are normally received by message, and specify the amount of funds allocated for

the project. Funding authorizations represent the maximum funds available for a specific project, and funds expended on the project can not exceed this amount without MAJCOM authorization and the allocation of additional funds.

It is important to compare the amount of the funding authorization with the funded cost listed on the DD Form 1391. The funding authorization will not necessarily match the amount requested on the DD Form 1391. A significant difference between the funded amount listed on the DD Form 1391 and the funding authorization may mean that a change in scope has been made. In any event, the amount specified in the funding authorization is the controlling figure, regardless of the funded cost listed on the DD Form 1391.

Manpower, Equipment, and Cost Estimates. A review of the cost estimates used to prepare the DD Form 1391 is necessary so that you are aware of the assumptions made and figures used to request funding for the project. Information on estimated costs should be contained in two separate documents contained in the project folder:

1. A summary of the estimated cost of the project is listed in block 9 of the DD Form 1391.

2. An engineers detailed estimate used to prepare the DD Form 1391 should be contained in the project folder, or be available from the project manager.

After locating this information you should look for some of the major costs associated with the project, such as total man days required, per diem rates, travel costs, and estimates of material costs.

At this point there is little you can do with this information; however after you complete your project schedule, you should verify the initial cost estimate in order to assure that sufficient funds will be available to complete the project. Procedures for verifying this initial cost estimate are discussed in Chapter XIII, Funds Management.

Project Drawings. A thorough review of the project drawings is necessary before any detailed planning or scheduling can be accomplished. If you do not have a set of project drawings, request a set from the project manager. The very first thing you should do with a set of drawings is to insure that they are current and contain the most recent revisions. This can be verified by the project manager and also by checking the project folder for any change orders. Also be aware that the drawings may be revised before the start of the project. In theory, you should be provided with revised drawings anytime a change is made; however, do not take any chances, check with the project manager from time to time to insure that your set of drawings is complete and up to date.

The purpose of a drawing review is to obtain a working knowledge of the project drawings. A working knowledge of the drawings requires that you have a basic understanding of the tasks required to complete the project and how these tasks are represented on the project drawings. As a minimum, you should be able to locate detail drawings,

understand all of the notes and symbols used on the drawings, and be able to locate certain key items such as building lines, column lines, key elevations, and the like.

While reviewing the drawings you must try to visualize what is being done. Be sure to read and understand all of the notes and detail drawings contained in the project drawing set. As you proceed through the drawing review, you should be constantly asking yourself the following questions:

1. How is the best way to accomplish each task?
2. What will be the sequence of each task?
3. What types of skills and equipment will be needed?
4. What types of problems might be encountered?
5. Where can I obtain additional information or clarification on things that I am unfamiliar with?

As you review the drawings, make a list of questions on things that are not clear or things that you do not understand. As you proceed through the drawings, some of your questions may be answered by notes, details, or other drawings in the set. After you have completed your drawing review, there will probably be some unanswered questions remaining. All questions should then be directed to the project manager.

Specifications. Specifications provide detailed information on methods of work, materials, tolerances, and construction standards. On most RED HORSE projects, a full set of specifications is not usually prepared by the design

engineer. Often times important specifications will be incorporated into the project drawings as notes. Pay particular attention to any specifications given, because during construction, it is your responsibility to insure that they are met.

Lab Test Results. During the design of the project, certain laboratory testing may have been accomplished. Two common items usually tested are soil samples and bulk materials such as aggregates or asphalt products. You should consult the project manager to discuss the significance of the test results if necessary.

Project Correspondence. The project folder should contain all correspondence pertaining to the project such as minutes of construction conference meetings, work directives, change orders, and related general correspondence. Reading the correspondence in the folder should give you a good background on the project history. While reading the correspondence, look for change orders, agreements made between parties, and any problem areas that have been identified.

After completing a review of the project records, you should have a good working knowledge of the project and be ready to begin preliminary project planning.

VIII. Project Meetings

Introduction

Project meetings are used to exchange information between key personnel associated with your construction project. Topics normally discussed at project meetings include such things as the project schedule; manning, equipment, and material requirements; transportation of equipment and materials to the site; and other problems that require special attention.

Organizing Project Meetings

You should schedule your first project meeting as soon as possible after you have familiarized yourself with the project. Project meetings should continue to be held on a regular basis until construction actually begins.

Your first step in organizing a project meeting is to discuss your role with the project manager. Often the project manager chooses to organize and chair the meetings himself. If this is the case, much of this section will not apply to you; however, you should be prepared to chair the meetings in the absence of the project manager. You should always be prepared to add points or raise important issues that the project manager may overlook during the meeting.

Sometimes project meetings are organized and held before the selection of a construction manager. If this is the case, then you should review copies of the minutes from all previous meeting in order to get up to speed on the status

of the various topics discussed. Again, you should discuss your role with the project manager.

If the situation requires you to organize the project meeting, the first thing you should do is to determine who should attend the project meetings. As a minimum, any shop or section which will be performing work or supporting the project should be represented. Besides the shops, be sure to consider the site development section, supply, vehicle maintenance, funds management, the planning section, and other appropriate activities.

Your first project meeting should be scheduled through the operations section. Each appropriate shop should be notified by letter stating the date, time, and place of the project meeting. Schedule your first meeting far enough in advance to allow all the various sections to respond. Section chiefs or shop supervisors will appoint representatives from their sections to attend the meetings. Besides attending the scheduled project meetings, these personnel will also be your primary point of contact concerning specific questions in their area of expertise.

Conducting Project Meetings

Be prepared to conduct an efficient meeting. Insure that you have at least one set of drawings for each shop and the planning section. Be prepared to brief the attendees on the important details of the project including any anticipated problems or special equipment requirements. You

should expect to be asked a variety of questions concerning the project, so be sure that you have a good working knowledge of the project before you schedule your first project meeting.

During the first meeting, you should review the drawings, pointing out major tasks and any problems that you anticipate. Ask each attendee to review the drawings applicable to his shop as soon as possible, and to bring any errors or questions to your attention. You should also advise the shop representatives that you will require their assistance when you are preparing the project schedule.

Bring up any unanswered questions you have concerning construction techniques or shop capabilities. The representative from the appropriate shop may be able to answer your question on the spot, or within a reasonable amount of time if further research is required. If the shop can not answer the question, the drawings may be incomplete or incorrect; therefore, you should notify the project manager immediately.

Another topic to discuss is material status. You should be interested in what is on order, what remains to be ordered, how much of material has arrived, and how and when the material will be moved to the construction site.

Ask the funds management representative about the current status of the project funds. Find out how much has been obligated so far, and the amount of funds remaining.

During the initial project meeting you may want to discuss who should attend the initial site visit. Any shop that will perform a significant portion of the work, or that may encounter any special problems during construction, may need to be represented on the initial site visit. In many cases, a single experienced individual may be able to represent several shops on the site visit.

Be sure that minutes are recorded during the meeting, and that each attendee is provided with a copy as soon as possible after the meeting. If possible, have an administrative person attend the meeting to record the minutes. If administrative support is not available, it is usually best for either the construction manager or project manager to take notes and later draft minutes from these notes.

Before adjourning the meeting, select a time and date for the next meeting. The interval between meetings can vary depending on the situation. In some cases monthly meetings may be adequate, in other cases weekly meetings would be more appropriate.

IX. Preconstruction Site Visit

Introduction

As soon as practical, you should make an arrangements to make a site visit to the project location. The objectives of a preconstruction site visit are:

1. To obtain a first hand knowledge of existing construction site conditions.
2. To coordinate host base support required to support the RED HORSE construction effort.

Planning the Site Visit

An initial site visit should be made as soon as possible after your appointment as a construction manager. The ideal time to make your first site visit would be after you have reviewed the project records but before you begin your detailed planning and scheduling.

Plan and coordinate your site visit through the project manager and the operations section to insure that all necessary personnel can accompany you. Also be sure to coordinate your site visit through the host base civil engineering squadron. You should be aware that each host base civil engineering squadron is required by AFR 93-9 to appoint a project officer to act as a liaison between RED HORSE and the base.

The Site Visit

Once you arrive at the host base, your first order of business should be to contact the project officer. You

should brief the project officer on the current status of your project including such things as estimated starting date, crew size, and any special requirements you might have.

The project officer should be able to provide you with the current status of any actions taken by the base to prepare for the project. Of primary importance is the current status of any materials ordered by the base for the project.

After your initial meeting with the project officer, you should visit the construction site. Before making a site visit, you should make a checklist of items to check at the construction site. Some of the most common things that should be included on your checklist are:

Project Location. The first and most obvious thing is to find out the exact location of the project site. Once you are at the site, be sure that you can orient yourself and the drawings properly. Insure that you know which direction is North.

Site Preparation. Once you have oriented yourself to the site, look at the general appearance of the project site. How much site preparation will be necessary before the project can begin? Are large areas of cut or fill required other than what is shown on the drawings? If the drawings show demolition work, do the existing structures match what is shown on the drawings? For example, if the drawings show a small shed to be demolished, check to insure

that that is an accurate description of the work involved, do not wait until the project begins to discover that the small shed is actually a heavily reinforced concrete bunker. Also look for other existing facilities that may be existing but not shown on the drawings. Typical examples are paved areas, trees, foundations, and existing structures.

Access to the Site. Look at exiting roads and access to the site. Are existing roads and access points capable of supporting heavy construction traffic? If suitable access roads are not available, it may be necessary to construct roads in order to deliver materials and equipment to the site.

Drainage. You should note existing surface drainage patterns. Where does surface runoff currently go? How will construction alter the drainage pattern? What will be necessary to insure that the project site freely drains during construction? Where will the surface runoff go during construction? Can existing drainage facilities handle any increased flows?

Soil Conditions. Look at the existing soil conditions, does the soil appear to be the same as shown on the drawings and soil test reports? Look at any existing open excavations in the project area, does the type of soil remain consistent or as shown in the drawings? Do you anticipate any problems with the existing soil?

Existing Utilities. Are there any existing utilities that will require relocation? Are they shown on the drawings? Before starting work, you must obtain an approved Construction Permit (AF Form 103). This permit should show any existing utilities in the project area; however, there may still be buried utilities in the area that are not shown on record drawings. Look for evidence such as long narrow depressed areas that may be utility trenches. If there are any manholes in the area, you may need to open them to determine the general direction in which the connecting lines are laid.

Storage and Work Areas. During construction, you will need a field office, equipment yard, and storage areas. Look for suitable locations, preferably on or adjacent to the construction site.

Renovation Projects. Look at the existing facility. Do the drawings accurately represent existing conditions? Are utilities actually in the areas shown on the drawings? Is all required demolition work shown on the drawings? Will any special tools or equipment be required for demolition work?

Other Areas. Your site visit should not be limited to the above areas. Other areas to look at may have been suggested during a project meeting, or may be obvious once you are actually at the project site.

Photographs. You should take several photographs of the project site area, concentrating on unusual or potential

problem areas. Photographs of the existing conditions on renovation projects are extremely important (2:75-76; 8:Sec 1,12).

The initial site visit should give you a good feel for the conditions you must contend with during construction. A first hand knowledge of these conditions will be a definite benefit to you during project planning, scheduling, and estimating. On renovation or other complicated projects, additional questions may surface as you move further into the planning phase, this may require that additional site visits be made.

Coordinating Host Base Support

The host base project officer should be your main point of contact for coordinating host base support. Some of the base support that you should arrange during your site visit includes:

Utility Service. If necessary, arrange for power and water service to the construction site through the base civil engineering squadron.

Construction Permit. Apply for a Construction Permit (AF Form 103) through the base civil engineering squadron. You should have several copies of the project site plan with the construction area clearly indicated, in your possession when you apply for the Construction Permit.

If time is available, the best way to obtain the Construction Permit is to hand carry the paperwork to each

coordinating agency or section. This entire process could take a few days, but will enable you to make personal contact with some of the key civil engineering and communications personnel on the base. Establishing points of contact in this manner usually results in a better working relationship with these sections during construction.

If you do not have the time to hand carry the Construction Permit paperwork, the civil engineering squadron will obtain approval for you. Be sure to follow up on the status of the permit to insure that approval is obtained before the scheduled start of your project.

Telephone Service. Telephone service is arranged through the base communications squadron.

Billeting. Notify the billeting office of your tentative plans for the deployment, including estimated size of the team, approximate arrival date, and length of stay. The billeting office should be able to inform you if quarters will be available during that period.

If off-base quarters will be used, be sure to find out the location of the quarters. In some cases, the nearest available quarters could be a long distance from the base and time lost traveling could significantly affect your project schedule. You may also need to make special arrangements for transportation to your off-base quarters.

Secure Storage Area. If required, arrange for a secure storage area through the base civil engineering squadron.

Disposal Area. Check with the project officer concerning appropriate disposal areas for debris and excess excavated material.

Administrative Support. Normally administrative support consists of typing reports and messages. Arrange for this support through the base civil engineering squadron.

Mail. Contact the base postal squadron to obtain a mailing address for the project.

Weather Reports. Contact the base weather service to obtain forecasts for the planned construction period.

Local Information

During your site visit, you should try to determine any local conditions that may affect your project. The base project officer should be able to help with the following items:

Local Policies. Check for any local policies or restrictions. This is especially appropriate in overseas areas, for example, some countries have restrictions on the length of military convoys, prohibit or restrict trucking operations on weekends or holidays, and may celebrate holidays that you may be unfamiliar with. This could seriously affect the progress of you job unless you have taken any restrictions into account when preparing your project schedule.

Material Contracts. You should confirm the availability and delivery rates for any bulk material such as concrete,

asphalt, aggregates or other materials that will be be provided under a contract. This check is necessary to insure that your project schedule is based on the amount of materials that can actually be delivered during a given period of time. Information on local material contracts is available through either the planning section or the material control section of the host base civil engineering squadron.

Trip Report

Upon the completion of your site visit, you should prepare a full trip report detailing the results of your findings and accomplishments. Be sure to included dates, names of people contacted, and any agreements made between parties. Submit the trip report to the operations section after coordinating with your supervisor.

X. Project Planning

Introduction

A good project plan is an essential element of successful construction management. Project planning consists of determining the construction tasks necessary to accomplish the project, their sequence, and the equipment and manpower required to support each task (8:Sec 1,6).

During the entire planning process, you should work closely with each shop or section involved with your project so that a meaningful project plan can be developed.

Work Elements

Work elements are major construction tasks that are necessary to complete a specific project. The first phase of project planning is to determine what work elements are applicable to your project.

The first step in this process is to review the Work Element Checklist contained in Appendix B. This checklist contains a listing of work elements common to many construction projects. The checklist is not complete but provides a good starting point for further analysis.

Using the Work Element Checklist as a guide, you should review each individual project drawing in order to identify all the work elements applicable to your project. Remember that the Work Element Checklist is just a general guide. Many of the work elements on the checklist may not be appropriate for your project and should be deleted from the

list. On the other hand, your project will probably contain some work elements not listed, so you will need to add them to your basic list as they are identified.

After comparing the Work Element Checklist with the drawings, prepare a list of all work elements appropriate for your project. Your work elements should be listed in the sequence that they will be performed. The Work Element Checklist follows a reasonable sequence of work and can be used as a guide.

Reference Material

In order to estimate manpower and equipment requirements you will need to obtain a reference book dealing with construction estimating. Two books dealing specifically with estimating for military construction projects are:

1. Army TM 5-333, Construction Management (8).
2. NAVFAC P-405, Seabee Planner's and Estimator's Handbook (15).

These books may be available from the operations section of your unit. If the books are not available, you should be able to obtain commercially prepared estimating books from either the engineering or operations section. A typical entry from an estimating book is shown in Figure 1. Most estimating books follow a similar format, listing the task, unit of measure, time required for each unit of work, suggested crew size, and equipment requirements.

Concrete Footings and Foundations

WORK ELEMENT DESCRIPTION	UNIT	MAN-DAYS PER UNIT		
		ADVERSE CONDITION	AVERAGE CONDITION	FAVORABLE CONDITION
Erect and strip forms	1000 SFCS*	70	44	22
Place reinforcing	Ton	16	10	5
Place, finish, and cure concrete	CY	0.7	0.4	0.2
For quick estimate: Concrete footing and foundation, complete	CY	3.4	2.0	0.8

Typical crew: 1 crew leader, 3 men erecting and stripping forms, 3 men placing reinforcing steel, and 4 men placing, spading, vibrating and finishing concrete.

* Square feet of contact surface.

Figure 1. Typical Estimating Table (13:67)

Work Element Summary Sheets

The first step in the estimating process is to prepare a summary sheet for each work element on your list. An example of a completed work element summary sheet is shown in Figure 2. You may want to modify the form shown in the example by adding additional column headings for unit of measure, suggested crew size, duration of task, and equipment requirements. This will give you a better idea of the work requirements for each subelement (13:56).

SHEET 1 OF 6

ESTIMATED BY Smith DATE 7-7-71

CHECKED BY Moore DATE 8-10-71

WORK ELEMENT ESTIMATE

SUMMARY SHEET

NMCB 133 LOCATION Okinawa YEAR 1971

PROJECT 08 DESCRIPTION Staging - Out Warehouse

WORK ELEMENT	QUANTITY	MAN-DAYS PER UNIT	MAN-DAYS REQUIRED
Footings and foundations			
Machine excavation	1860 c.y.	40/1000 c.y.	74.4
Machine backfill	1277 c.y.	6/1000 c.y.	7.7
Hand Compaction	1277 c.y.	0.30/ c.y.	383.1
Spread excess - earth machine	583 c.y.	1.6/1000 c.y.	0.9
Form and strip	11,083 SFCS	44/1000 SFCS	487.7
Place reinforcing steel	34.6 tons	10/ton	346.0
Place, finish, & cure Concrete	582.8 c.y.	0.75/c.y.	437.1
Total	Man-days		1736.9

Figure 2. Work Element Summary Sheet (13:71)

A separate summary sheet should be completed for each work element on your list. Separate worksheets will help you organize your work, plus provide room for listing any required subelements of work under each major work element (13:67). When making your work element summary sheets, be sure that your column headings conform to the particular estimating guide that you are using. For example, instead of using man-days per unit, some books may use man-hours per unit or daily output per suggested crew size.

Next, using the reference book that you have available, you must locate the appropriate estimating tables for each work element. Estimating tables found in most reference books usually contain a listing of subelements that fall under the major work element category. You should select the subelements appropriate to your project and list them on the work element summary sheet. For example, in Figure 2, the work element Footings and Foundations is broken down into seven subelements.

From the estimating tables, you should be able to obtain information on the unit of measure, man-days required per unit, suggested crew size, special skills required, and major pieces of equipment necessary for each subelement. This information should be recorded on your summary sheet in the appropriate column. If you did not modify the form to include additional headings for suggested crew size and equipment requirements, you should record this information at the bottom of the summary sheet.

Quantity Surveys

In order to fill in the quantity column, you must perform a quantity survey. A quantity survey is a detailed list of the amount of material required or work necessary on the entire job. The purpose of making a quantity survey is to determine the amount of work associated with each subelement listed on each summary sheet. A quantity survey is similar to a material takeoff, but in addition to listing

material requirements, a quantity survey also lists the type and amount of work involved that does not require the procurement of materials. Some examples of work elements not requiring materials are excavating, grading, and finishing concrete.

You should be able to obtain a majority of the information required for your quantity survey from the planning section. The planning section completes a detailed material takeoff prior to ordering materials. This information is then used to prepare a bill of materials which lists all of the materials that are required for the project. You should contact the planning section chief to obtain a bill of materials for your project.

Usually the planning section only estimates material requirements. This leaves you with the task of estimating quantities for such things as earthmoving, trenching, and other tasks that do not require purchased materials.

Remember that even though the planning section may have prepared a bill of materials, as construction manager it is still your responsibility to insure that it is correct. While you are preparing your quantity survey, you should make some rough checks on the quantities listed on the bill of materials. If you find any discrepancies, contact the appropriate planner for clarification.

When you are accomplishing the quantity survey, be sure that the units that you are working with are consistent with the estimating tables used in the particular reference you

are using. Information on the proper unit of measure should have been previously recorded on your work element summary sheet for each individual subelement.

When you have completed the quantity survey, this information should be recorded under the quantity column for each subelement of work.

Tentative Manpower and Equipment Requirements

Once the quantities are recorded on the work element summary sheets, calculate the man-days required for each subelement by multiplying the quantity column by the man-days per unit column. The resulting figure is then recorded in the man-days required column. The total man-days required for the work element is obtained by adding the man-days required for each subelement. The duration of each work element depends on the manpower assigned to each subelement. Manpower assignments will be determined during the scheduling process.

Equipment requirements should also be listed on each work element summary sheet. The type and suggested quantity of major pieces of equipment necessary to accomplish each work element can be found in the estimating tables. You should also review the Equipment and Tool Checklist contained in Appendix C in order to determine other pieces of equipment that may be required.

The manpower and equipment requirements obtained from the estimating tables are tentative requirements used only for planning purposes. Detailed crew and equipment assignments will be made during the scheduling process discussed in Chapter XI.

Sequencing Work Elements

The final phase of project planning involves sequencing the work elements, determining relationships between work elements, and showing this information graphically using either an Arrow Diagram or Precedence Diagram (15:Sec 5,2). According to the Seabee Planner's and Estimators Handbook, Precedence Diagrams are now preferred over Arrow Diagrams because Precedence Diagrams are more compatible with computer programs used for project scheduling, less complicated, and easier to draw (15:Sec 5,24).

Precedence Diagrams

The drawing of a Precedence Diagram should be a joint effort between the project manager, the construction manager, and each shop or section involved with the project.

The basic rules of drawing Precedence Diagrams are:

1. Work elements are represented by boxes and referred to as activities.
2. Each activity is assigned an activity number.
3. The left side of each box represents the start of the activity.
4. The right side of each box represents the completion of the activity.

5. Activities that must be performed in a certain sequence are connected with lines called connectors.

6. Activities that can be accomplished simultaneously are not connected.

7. An activity can not begin until all preceding activities linked to it have been completed (15:Sec 5,24-25).

A simple Precedence Diagram is shown in Figure 3. Applying the above rules, the diagram shows that activities 2 and 3 can be accomplished at the same time, but neither can begin until activity 1 has been completed. Activity 4 can not begin until both activity 2 and 3 have been completed (15:Sec 5,25).

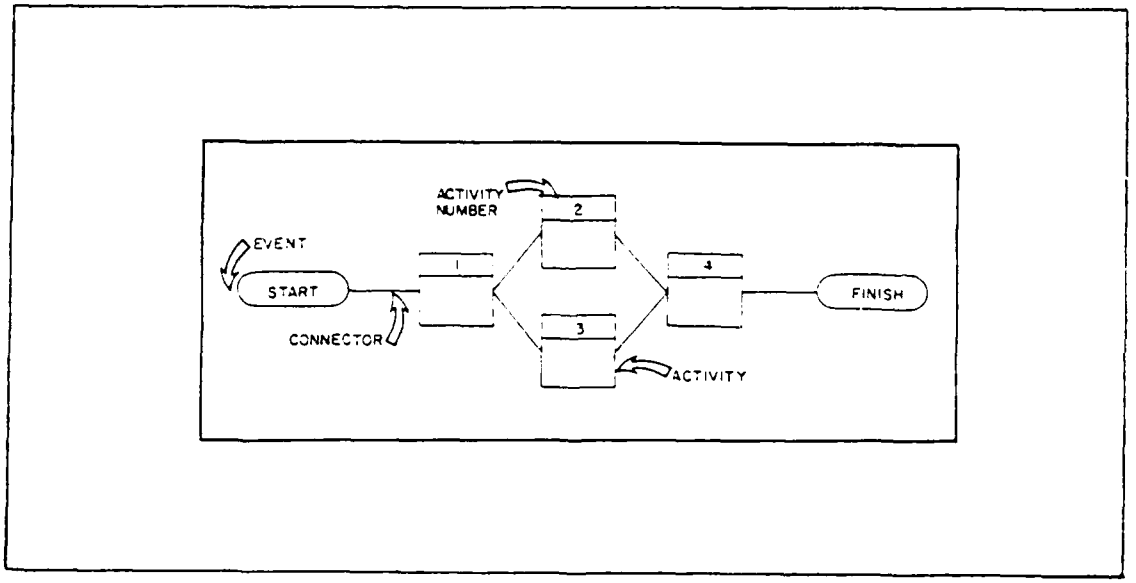

Figure 3. Precedence Diagram (15:Sec 5,25)

In order to draw a Precedence Diagram for your project you should list each of your work elements on an index card. The cards can then be laid out on a table and arranged in a logical sequence (15:Sec 5,29). This should be fairly

straight forward if you developed your work element list in the sequence that the work will be performed.

You may need to limit that amount of activities used in your Precedence Diagram. To be useable, your Precedence Diagram should contain enough activities to present a complete picture without becoming confusing. To reduce the number of activities used, you can combine work elements that are similar or related, and represent them as single activities on the Precedence Diagram.

Next, determine the relationship between activities. Draw connectors between activities that are related or must be performed in a specific sequence. You may have to rearrange your activity cards several times before you obtain a satisfactory layout. Be sure to make a good drawing of your completed Precedence Diagram.

XI. Scheduling

Introduction

Scheduling involves developing a formal plan of action for the execution of your project. This section discusses how work element summary sheets and Precedence Diagrams are used to develop a project schedule.

The first step in the scheduling process is to determine the manning and equipment requirements necessary to accomplish your project. You should develop your resource requirements in close coordination with the project manager, the operations section, and all other sections involved with your project. This will prevent you from making plans to utilize men or equipment that may not be available for your project.

Manning Requirements

The first step in determining manning requirements is to look at your work element summary sheets and Precedence Diagram as a whole. The summary sheets contain information on the tasks, manpower, and equipment required to complete each activity, and the Precedence Diagram shows the relationship and dependencies between activities. Together, the summary sheets and diagram show you how personnel will be able to move between different activities as the project progresses.

An estimate of the duration of a work element or subelement can be made by dividing the man-hours required by

the number of men assigned. This figure will help you obtain a good balance between the amount of work involved in each activity and the size and make up of the crew assigned to accomplish the work.

Next you should make tentative work assignments against each activity. When making crew assignments, be sure to utilize personnel with the appropriate skills necessary for each task.

As a starting point for making crew assignments, you can use the suggested crew sizes obtained from the estimating tables, and listed on your summary sheets. Another method of making initial crew assignments is to rely on recommendations from personnel experienced in the particular activity involved. In either case, your initial crew assignments will probably change several times before you complete this process.

When making crew assignments, you should consider how each individual or crew will be used during the entire project. For example, when a person of a particular skill or trade completes his work on one activity, what activity will he be assigned to next? Possibly, because of the precedence relationship between activities, there may be no activity ready for his specific skill, if this is the case, where can this person be utilized until the next activity requiring his specific skill begins? When you are finished with your initial crew assignments, you should have a good

idea of what each individual or crew will be doing during the entire period that they are assigned to your project.

Once you have made crew assignments against each work element, you should prepare a list summarizing the total number of men, by skill, that will be required for your project. If you have been coordinating your work assignments with the operations section throughout this process, your manning requirements should have been based on using manpower that is expected to be available during the construction period of your project. After completing your manning list, you should ask the operations section to confirm that the manpower and skills necessary for your project will be available.

Equipment Requirements

Equipment requirements are determined following the same procedure described above. A starting point for determining equipment requirements can be obtained from either your work element summary sheets or from consultation with personnel experienced in the particular activity involved.

Some additional factors to consider when determining equipment requirements are, the type of material being handled, haul distances, operating speeds, and mechanical reliability of the the equipment. Backup units for key pieces of equipment may also be necessary (15:64-65).

You should also consider the movement of the equipment between tasks, for example, when an activity is completed,

what activity will the equipment be assigned to next? Look at activities that may be planned for accomplishment at the same time, will you have enough equipment to support both activities? If not, you may need to reschedule an activity or determine how your available equipment can be scheduled to support both activities.

Be sure to coordinate all of your equipment requirements through the operations section throughout this entire process. This coordination is necessary to insure that equipment will be available for your project.

Activity Durations

Basically, the duration of each activity or work element is determined by dividing the total man-days required by the number of personnel assigned to accomplish the work. Because the production rates listed in estimating references are based on average working conditions, you may need to add additional time to the calculated durations in order to allow for any conditions that can adversely affect your project. Some of the things that could adversely affect production rates are:

1. Heavy or rushed workloads.
2 Congested work areas.
3. Inexperienced workers or supervisors.
4. Undermanning of critical skills.
5. High quality work required.
6. Poor weather conditions.

7. Unreliable equipment.

8. Equipment shortages.

9. Slow delivery of supplies (15:Sec 4,3).

The best way to determine how these factors might affect your project is to discuss them with personnel from the appropriate section. For example, the supply section can advise you of any anticipated material problems, the equipment section will be able to address equipment availability, and supervisors or other construction managers can provide information on workers.

After considering how the above factors might affect your project, it may be necessary to increase the calculated duration of some activities. Each activity on the project schedule should be considered separately, for example, weather conditions could seriously affect excavation work, but have little or no effect on interior finish work.

Determining the amount of time to increase an activity to compensate for any adverse conditions should be based on your best judgement. Depending on the circumstances, increases of 5% to 25% would not be uncommon, and under extremely bad conditions, increases of % or more may be appropriate (15:Sec 4,2-3). Your work element summary sheets should be updated to reflect any revised durations.

Scheduling Using the Precedence Diagram

Scheduling with a Precedence Diagram uses the same rules used for Critical Path Analysis. Information pertaining to

each activity on the Precedence Diagram is recorded in each activity block using the format shown in Figure 4.

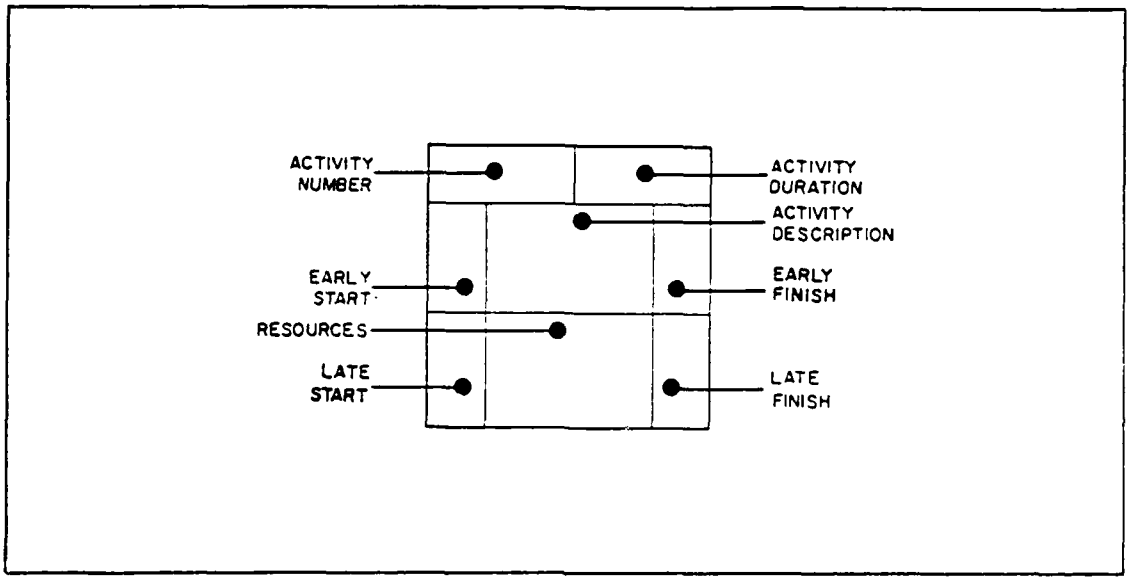

Figure 4. Information for a Precedence Diagram (15:5,29)

Time related information used on Precedence Diagrams is usually in units of work-days. Work-days do not correspond to calendar days unless you are planning to work seven days a week. After completion of a schedule based on the Critical Path Method, the schedule will be converted into a construction schedule based on calendar days.

The following information describes how to properly complete the activity blocks on your Precedence Diagram.

Activity Description. The activity description can be the name of the major work element involved, or any other name you choose to call it providing it reflects an accurate description of the work involved.

Resources. In this block you should list the manpower and equipment resources required for the activity. You should be specific, listing manpower requirements by trade or skill, and the specific type and quantity of equipment required for each activity.

Activity Number. Activity numbers are assigned to each activity in the order that they appear on the Precedence Diagram.

Activity Duration. Activity durations are calculated by dividing the total man-days required by the number of personnel assigned to the activity.

Early Start Day. The early start day is the earliest day that an activity can start. To calculate early start times, assign an early start day of 0 to activity 1 and any other activities that will begin at that time. Then following the flow of your Precedence diagram, calculate the early start for every other activity in your diagram. Early start times are calculated for each activity by adding the early start time and duration of the preceding activity.

For example, in Figure 5, the early start time for activity 15 is found by adding the early start time of activity 14 with the duration of activity 14. In this case the early start time of activity 15 is (16 + 3) = 19.

If the start of an activity is dependent on the completion of two or more preceding activities, the procedure becomes a little more complicated. For example in Figure 5, activity 24 can not begin until activities 16, 21,

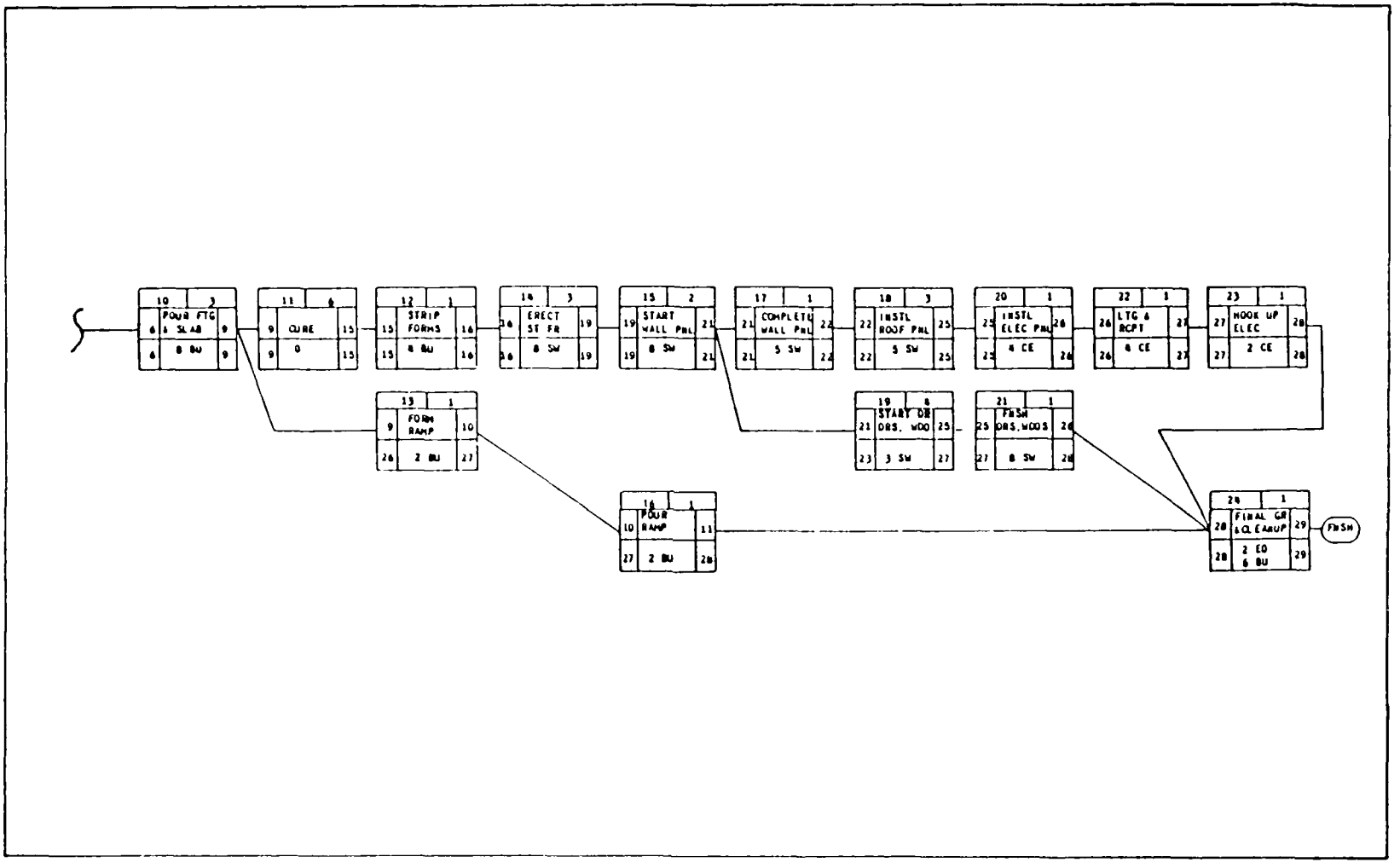

Figure 5. Partial Precedence Diagram (15:Sec 5:31)

and 23 are completed. First, tentative early start dates for activity 24 must be computed based on the three preceding activities. In this example, tentative early start dates for activity 24 are as follows; early start based on activity 16 is (10 + 1) = 11; early start based on activity 21 is (25 + 1) = 26; early start based on activity 23 is (27 + 1) = 28. The early start date for activity 24 is then determined by selecting the largest of the three possible figures, in this case 28.

Early start dates should be determined for all activities on the Precedence Diagram before proceeding any further.

Late Start Day. The late start day is the latest day that an activity can begin without delaying the project. Late start dates are calculated by starting at the end of the project and working backwards to the beginning.

The first step in this process is to begin with the last activity on the Precedence Diagram. Set the late start date of this activity equal to the early start date. For example, in Figure 5, the late start date of activity 24 is 28, the same as the early start date.

Late start dates for other activities are calculated by subtracting the duration of the activity from the late start date of the activity that immediately follows the activity. For example, in Figure 5, the late start date of activity 17 is found by subtraction the duration of activity 17 from the

late start date of activity 18. In this case, the late start of activity 17 is (22 - 1) = 21.

In the event that two or more activities follow the activity you are working with, tentative late start dates must be calculated before the late start date of the activity can be determined. In Figure 5, activity 15 is followed by activities 17 and 19. To determine the late start date for activity 15, you must first calculate tentative late start dates based on both activities 17 and 19. The tentative late start date based on activity 17 is (21 - 2) = 19. The late start based on activity 19 is (23 - 2) = 21. The late start date for activity 17 is then the smaller of the two figures, in this case, 19.

As a check, the Precedence Diagram should have at least one activity with a late start date and an early start of 0. You should determine all the late start dates on your Precedence Diagram before starting any other calculations.

Early Finish Day. The early Finish day is the earliest day that an activity can be finished. The early finish date for the last activity on the Precedence Diagram represents the total project duration in work-days. Early finish dates are calculated by adding the early start date to the duration of the activity. For example, in Figure 5, the early finish date for activity 18 is (22 + 3) = 25.

Late Finish Day. The late finish day represents the latest date that an activity can be completed without delaying the project. Late finish dates are calculated by

adding the late start date to the activity duration. For the last activity on the Precedence Diagram, the late finish date and the early finish date will be the same.

The Critical Path

When your Precedence Diagram is complete, you can use it identify the critical path, or the longest path through the network. The significance of the critical path is that a delay in completing any activity on the critical path will result in delaying the entire project. Before determining the critical path, activity float must be calculated and critical activities must be identified.

Float. Float represents scheduling leeway for a particular activity. Float is calculated by subtracting the early start date from the late start date. Float should be recorded on the Precedence Diagram next to each activity block.

Critical Activities. A critical activity is any activity that will delay the entire project if it is not completed on schedule. Critical activities are activities that have no scheduling leeway; therefore, activities with floats of 0 are critical activities (2:281). You should highlight critical activities on the Precedence Diagram.

Critical Path. The critical path is the path through the Precedence Diagram that connects all of the critical activities. The critical path is the longest path through the Precedence Diagram. You should be able to trace the

critical path continuously through the diagram from start to finish. The length of the critical path is equal to the project duration.

If the critical path on your Precedence Diagram is not continuous from start to finish, you have a mistake in your diagram and you should recheck all of your calculations. You should be aware that it is possible to have more than one critical path on your diagram (8:Sec 2,6). Once you are satisfied with the diagram, the connectors between critical activities should be darkened in to show the critical path.

The critical path is useful because it identifies activities that must be completed on schedule to avoid delaying the completion of the project. In order to shorten the duration of a project, the length of the critical path must be shortened. Knowledge of the critical path helps a construction manager identify the best possible use of his resources at any given time, plus enables him to assess the consequences of rescheduling or delaying activities.

Major schedule changes or delays can affect the critical path, causing noncritical activities to become critical. Therefore, it is necessary to update the Precedence Diagram from time to time during the life of the project (8:Sec 2, 3-13; 15:Sec 5,6-12).

Project Schedules

All of the scheduling information contained on the Precedence Diagram is measured in units of work-days. The

next step in the scheduling process is to develop a project schedule based on this information.

This first step in this process is to transfer the scheduling information contained on the Precedence Diagram onto a more traditional type of schedule. The best way to do this is to begin the schedule on a piece of graph paper that is divided into small squares. Activity names are listed down the left side of the paper, and workday numbers are listed across the top as shown in Figure 6.

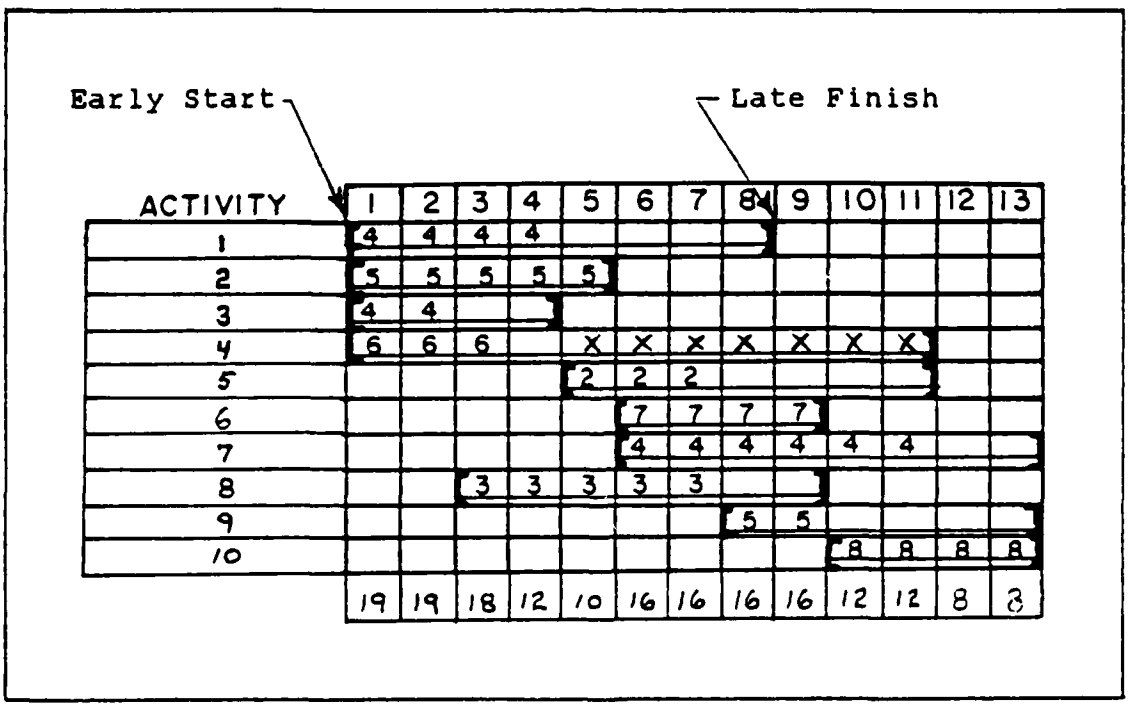

Figure 6. Project Schedule (8:Sec 2,9).

Early start and late finish dates for each activity are transferred from the Precedence Diagram to the schedule, and indicated by heavy brackets as in Figure 6.

Once the early start and late finish brackets are in place for each activity, transfer the manpower requirements and durations for each activity from the Precedence Diagram onto the schedule. Your initial schedule should be based on starting each activity on the early start date. When you record the manpower for each activity, you should also indicate the particular skill or shop that each figure represents (8:Sec 2,8).

Equipment requirements should also be considered when developing the project schedule. Equipment requirements can be listed on the schedule along with the number of craftsmen needed.

Rescheduling Activities

Looking at Figure 6, activity 1 requires four men four days to complete, and is scheduled to begin on day 1 and be completed on day 4. Note that there are four empty days remaining between the the completion of the activity and the late finish bracket. These unused days represent the total float for activity 1. This means that the start of activity 1 could be delayed four days without delaying the project.

Critical activities have no float, and will therefore occupy all the spaces between the early start and late finish brackets. Activities 2, 6, and 10 in this example form the critical path. Any delay in completing any of these activities on schedule will delay the completion of the project by an amount of time equal to the delay.

Once you have all of the manpower requirements filled in on the schedule, you can look at the entire project and try to balance your manpower. For example, assume four carpenters are required for activities 1 and 3. As the schedule stands now, a total of eight carpenters are required on days 1 and 2, and four carpenters are required on days 3 and 4.

To balance the workload, you could reschedule the activity 1 using the available float time. For example, activity 1 can be rescheduled from days 1-4 to days 3-6. This change would not affect your overall project schedule because activity 1 will still be completed before the late finish date. The advantage to making this schedule change is that your requirement for carpenters is now leveled off to four carpenters working on days 1 through 6. Remember that critical activities can not be rescheduled without affecting the duration of your project.

You should also try to balance the total number of personnel assigned to your project. For example, the daily manpower total shown in Figure 8 varies from day to day. You may be able to balance these figures somewhat by rescheduling some activities, but you will always have some variation in the daily totals.

In actual practice, the size of the crew assigned to a project will remain fairly constant during different phases of the project. The difference between the total manpower assigned to the project and the total manpower scheduled

each day represents available manpower that can be assigned as desired by the construction manager.

Equipment requirements should also be taken into account when considering schedule changes. Some activities may need to be rescheduled in order to make the most efficient use of your equipment resources.

Interfering Float

One thing to be aware of whenever rescheduling work is interfering float. Interfering float results when the total float for an activity could interfere with a following activity. Interfering float is indicated by an X in the total float area of an activity.

Before making any schedule changes, you should check the precedence relationships between activities. For example, assume the Precedence Diagram for the schedule shown in Figure 6 shows that activity 5 can not start until activity 4 is complete. Activity 4 has a total float of eight days, but only one day of free float is available, the remaining seven days of float is called interfering float. The reason for this is that if activity 4 is rescheduled later than day 4, it will cause a delay in starting activity 5 (8:Sec 2, 8-10).

You can gain additional available float time for activity 4 by rescheduling activity 5. In this case, you could gain the largest amount of available float for activity 4 by rescheduling activity 5 to days 9-11. This

would result in free float of five days for activity 4, but leave activity 5 with no available float.

Construction Schedules

Once a firm start date for your project has been set, you can convert the project schedule which is based on work-days into a construction schedule based on calendar days. A construction schedule is similar to a project schedule except that actual calendar dates are added to the schedule. When figuring the calendar dates that correspond to workday numbers, be sure that you count only actual workdays. For example, if you plan to work six days a week, with Sundays off, then if workday 6 corresponds to the date for Saturday, the date for workday 7 would correspond to the date for Monday. The reason for this is that all of the dates on the Precedence Diagram were calculated on total number of days work required to complete the task. If you fail to consider non-workdays when determining the calendar dates that correspond to these workdays, the time frame for your construction schedule could be significantly compressed, making it impossible to meet scheduled completion dates.

When making your construction schedule, you should be aware of any local holidays or work restrictions that could affect your schedule. For example, you may plan on placing concrete seven days a week, but if concrete is being supplied by a local contractor, you may receive deliveries

only six days a week, so your schedule should take this into consideration. Local holidays, especially in overseas areas, could also significantly affect material deliveries, and should not be overlooked.

Progress Schedules

Progress schedules are used during construction to monitor job progress. The most widely used type of schedule used for monitoring job progress is the rectangular bar chart (18:Sec 4,14). Bar charts are used to show scheduled starting and completion dates for each activity, the relationship between activities, and actual verses scheduled progress.

After completion of the construction schedule, you should develop a progress schedule in the form of a bar chart. Information needed to construct a progress schedule is obtained from your construction schedule. To keep the progress schedule simple and easy to use, the schedule can be based on time periods of weeks or months rather than days. Actual dates for the scheduled start and completion of each activity can be shown next to each activity rectangle. Every activity shown on your construction schedule should be shown on the progress schedule.

A typical progress schedule used for monitoring job progress is shown in Figure 7. The chart has been updated to show progress as of the end of December. At this point in time, the chart shows that excavation work was started on

time and finished ahead of schedule. The formwork was started late, but is currently on schedule and 60% complete (18:Sec 4,15).

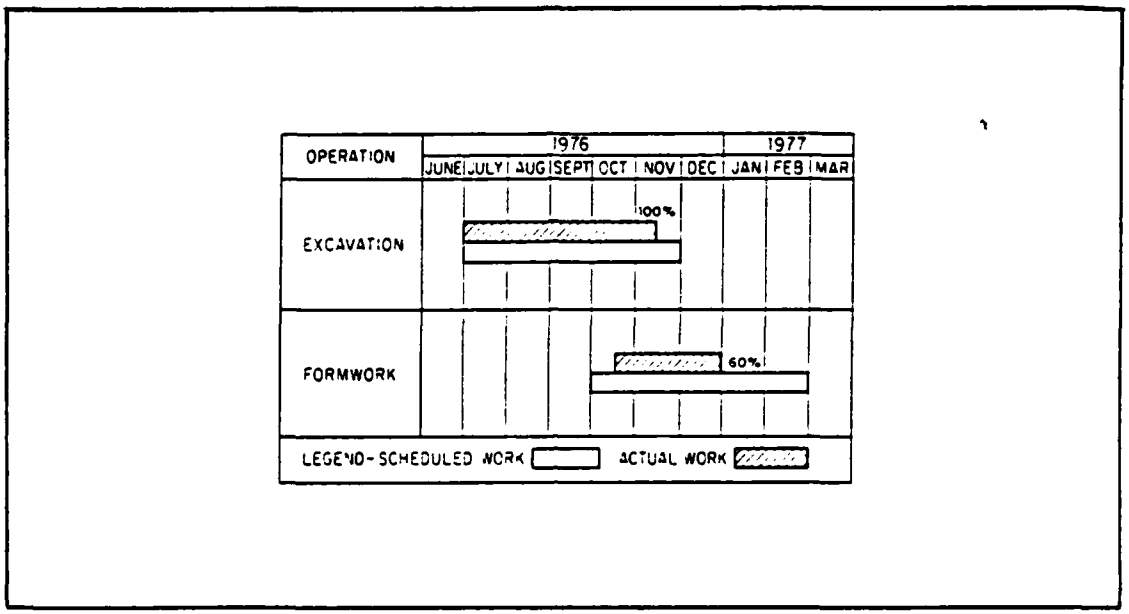

Figure 7. Progress Schedule (18:Sec 4,14)

XII. Organizing the Construction Team

Introduction

This chapter covers the actions necessary to organize a construction team before the start of a project. Topics include crew and equipment selection, team briefings, and coordinating actions necessary to insure a smooth deployment.

Crew and Equipment Selection

Once a specific starting date for your project has been established and your construction schedule has been completed, you have all the information necessary to submit a formal crew and equipment selection request. A formal crew selection request involves identifying your manpower requirements to the operations section in writing. To prepare the request, you need to identify your specific requirements concerning the number of personnel needed, the skills required, and the dates they will be required. When you prepare your crew selection request, do not overlook any requirements you may have for skills such as supply, vehicle maintenance, site development, and administrative support.

Normally, on large projects, initial manning starts out low during the initial phases of the project and is increased as additional work areas become available. On smaller projects, or large projects that involve only a few repetitive tasks, your manning requirements may remain the same throughout the project. Manning requirements during

the different phases of the project can be determined from the construction schedule.

Once the operations section receives your crew selection request, the various sections and shops can select the personnel that will be assigned to your project. The operations section will inform you as soon as your crew has been selected.

At the same time you submit your crew selection request, you should also submit a written equipment requirement list. This list should be specific, listing the amount and type of equipment required, and the dates when it will be needed.

Coordinating Activities

Once your project schedule is complete, you have a plan of action based on specific dates and numbers of people. Now you will be able to finalize such things as billeting arrangements and transportation requirements.

Initial coordination of these activities should be through the operations section. In most cases, the operations section will make billeting and travel arrangements for your crew, but it is your responsibility to confirm that the proper arrangements have been made.

The operations section will also have orders published for your crew. It is the construction manager's responsibility to provide the operations section with all of the necessary information for the orders in a timely manner. Several days prior to your deployment, check to insure that

the orders are ready and that billeting and transportation arrangements have been confirmed.

Once construction begins, you should monitor your construction progress closely to insure that the manning scheduled for various phases of the project arrives when needed. This requires close coordination with the operations section because it often requires rescheduling the manpower assigned to your project. For example, if work is running ahead of schedule, you will have to request that any incoming crews be expedited. On the other hand, if a portion of work is behind schedule, you should ask that any follow on crews that will be affected by this delay be rescheduled to arrive at a later date.

Crew Briefings

Once your crew has been identified, you should hold a project meeting with the lead craftsmen from each section or shop. Lead craftsmen should be utilized as work leaders during construction, so it is essential that they have a thorough understanding of the work involved on the project. During your meeting with the lead craftsmen, you should brief them on the details of the project, and provide each individual with a set of project drawings.

Next, an equipment and tool list for each shop should be developed. To begin the list, start with the Equipment and Tool Checklist contained in Appendix C. Other equipment and tool requirements will probably be identified by the lead

craftsmen. Once all of the requirements are known, a checklist for each shop should be made. You should task each lead craftsman to insure that the men in their respective shops that are assigned to the project, deploy with all of the equipment and tools necessary to accomplish the work involved.

Shortly before deploying, brief your entire crew on the details of the project. In additional to informing them about the project, you should also cover such things as duty hours, discipline, work standards, job performance, and any other matters of importance. Making your policies and expectations known before deployment can alleviate many potential problems or misunderstandings that might otherwise develop on the construction site.

Once construction begins, additional men may be phased into your project as work progresses. Be sure that you brief new men on your policies and expectations as soon as possible after their arrival.

XIII. Funds Management

Introduction

This chapter discusses the construction manager's role in the management of project funds. Topics covered in this section include funded and unfunded costs, record keeping, and project status reports.

Project Costs

Costs associated with RED HORSE construction projects are broken down into three categories; funded costs, unfunded costs, and excluded costs. Total project cost includes funded and unfunded costs (5:12).

Funded Costs. Funded costs are costs that are charged directly against the funds appropriated for a specific project. Funded costs require close control because the total of all funded costs charged against the project cannot exceed the project funds available. Funded project costs include the following:

1. Labor costs, including in-service civilian labor and foreign nationals, but excluding U.S. military labor costs.
2. Material costs, for materials purchased for a specific project.
3. Real property installed equipment, except when the purpose of the project is to relocate the equipment.
4. Second-destination transportation costs, but only when they can be identified to a specific project.
5. Contract services, if applicable.
6. Construction agency overhead for design or inspection, such as the Army Corps of Engineers, the

Naval Facilities Engineering Command, or for projects in the United Kingdom, the Property Services Agency.

7. Travel and per diem costs.

8. Rental equipment costs.

9. Fuel costs (5:12-13).

The project manager will be able to tell you which of these funded costs will be applicable to your project. As a general rule, the most common funded costs that a construction manager will be concerned with during construction are:

1. Material costs.

2. Travel costs.

3. Per diem costs.

4. Equipment rental costs.

5. Fuel costs.

Unfunded Costs. Unfunded costs represent costs incurred by the Air Force, but not charged against project funds. Unfunded costs must be accounted for mainly for record keeping purposes and are not usually affected by any funding limitations.

The following costs are classified as unfunded costs:

1. Military labor costs, including training and construction supervision.

2. Equipment depreciation costs.

3. Non-Air Force equipment and material costs.

4. Planning and design costs for projects funded from P-341 funds (funds used for emergency projects).

5. Donated labor and material (5:13).

The project manager will inform you of the unfunded costs that will be applicable to your project. The most common unfunded costs that construction managers will be concerned with during construction are:

1. Labor costs.
2. Training costs.
3. Equipment and vehicle depreciation costs.

Excluded Costs. Excluded costs are not considered a part of the total project cost. Excluded costs will be identified on the DD Form 1391c, Military Construction Project Data, which is maintained in the project folder. Excluded costs include:

1. Equipment that is not included on real property records.
2. Real property equipment when the purpose of the project is to relocate the equipment.
3. Command site visits or design reviews (5:13).

Current Working Estimate

As soon as your project schedule is complete, you should give a copy of the schedule to the project manager so that the information can be used to update the current working estimate. Before construction begins, project managers are responsible for insuring that the estimated project cost does not exceed the funded cost of the project (4:32).

Even though the responsibility of comparing the current working estimate against the funded cost of the project rests with the project manager, a construction manager

should be familiar with the process of making a current working estimate. Once construction begins, the construction manager will be responsible for tracking project costs, so it will be a definite advantage for a construction manager to be as familiar as possible with all aspects of project funding.

The original cost estimate used to request project funds is usually based on historical cost records rather than a detailed analysis. This is necessary because some projects are not completely designed until the programming documents are approved, and materials are not purchased until the project is funded.

A current working estimate based on a detailed project schedule and an actual bill of materials should be much more accurate than the original estimate. The current working estimate should include only funded costs.

The planning and cost accounting sections should be able to provide you with the cost of materials purchased to date, and an estimated cost for materials still to be purchased. If materials are being purchased by both RED HORSE and the host base, be sure to obtain cost figures from both squadrons.

Some materials, such as concrete or asphalt may not have been purchased yet, but you should know the quantity required, and the planning section should be able to give you a good estimate of the unit cost of the material.

Travel and per diem rates can be obtained from the travel section of the base accounting/finance office. You should obtain travel costs for both military and commercial methods of travel, and per diem rates for both on-base and off-base quarters. The operations section should be able to confirm your method of transportation and the availability of on-base quarters.

Travel and per diem costs can be estimated by using information that is available on your project schedule. Travel costs are estimated by multiplying the number of personnel movements to and from the project location by the appropriate travel cost.

Per diem costs are estimated by multiplying the number of man-days on site by the appropriate per diem rate. Be sure to use calendar days on site rather than work-days when estimating per diem costs. Also, per diem rates are usually different for officers and enlisted men, so be sure to use the correct rate for your estimate.

Fuel consumption can be estimated by multiplying the fuel consumption rate for each piece of equipment by the estimated usage of the equipment. Fuel consumption rates are available from either the operations section or the shop to which the equipment is assigned. An estimate of how much each piece of equipment will be used can be made by referring to your project schedule.

Fuel costs are estimated by multiplying the total fuel consumption by the price of fuel. The operations section

can provide you with the correct figures to use for the current price of gasoline and diesel fuel.

Equipment rental costs are estimated by multiplying the estimated rental cost by the expected usage of the equipment. Rental costs may be based on hours of use, miles driven, or specific periods of time, so your estimate should be made accordingly.

Other funded costs discussed earlier may be applicable and should be included in the total estimated funded cost. Once you have estimated all of the funded costs for the project, you should increase the total estimate by at least ten per cent to allow for contingencies and unforeseen problems. A higher allowance should be used when you can reasonably expect delays due to poor weather conditions, delays in receiving materials, unforeseen site conditions, or when the project is a new type of work being undertaken for the first time.

Next, compare the current working estimate against funded amount of the project. If the current working estimate comes close to, or exceeds the project funds available, you should discuss the situation with the project manager. It may be necessary to modify the construction plans, or to reevaluate the construction schedule. In most cases, close management of project funds during construction will enable the project to be completed within the allowable budget.

Current working estimates should be updated as more information becomes available. Once construction starts, current working estimates should continue to be made based on actual expenses to date and estimated expenses for the remainder of the project. Keeping your current working estimate up to date will help to identify and avert potential funding problems.

Record Keeping

Once your project begins, AFR 93-9 requires that both funded and unfunded costs be reported weekly (4:33). This requires that detailed records of all costs be kept.

Before starting your project, you need to obtain information on the current standard costs used for project cost accounting. Standard costs are costs that have been established for cost accounting purposes and apply to all projects regardless of the location. Typical standard costs are the shop rate used to determine military labor costs, fuel costs, and vehicle depreciation costs. The operations section will provide you with the current standard costs to use for your project. These costs are updated periodically, so be sure that you obtain the current figures before the start of your project. If the costs change during your project, the operations section will inform you of the new rates.

Travel costs and per diem rates can be obtained from the travel section of the base accounting/finance office. These

rates sometimes change during the life of a project, so you should contact the finance office every month to insure that the rates you are using are current.

One way to maintain cost accounting records is to use a series of log books for record keeping. To facilitate record keeping and reporting, your project records should be set up so that they can be closed out on a weekly basis. A method that can be used to set up and maintain cost accounting records using a series of log books is described below:

Personnel Log. A personnel log is used to maintain a weekly record of the personnel assigned to your project. To facilitate weekly reporting, new pages are started each week. Names of personnel are listed down the left side of the page, and column headings for seven calendar days are listed across the top. Additional columns are added for per diem and travel costs. An example of a personnel log is shown in Figure 8.

To use the log book, you should list any person that was assigned to your project during any part of the week. The number of hours each person works each day should be recorded in the appropriate column. Whenever a person arrives or departs the project location, this should be clearly marked in the column representing the day of arrival or departure.

Training costs are unfunded costs, so personnel in training status should be clearly identified in the log

WEEK 7
9-15 APRIL

NAME	SHOP	9	10	11	12	13	14	15	TOTAL HOURS	TRAVEL (ONE WAY) $80	PER DIEM ON SITE $10/DAY	PER DIEM TRAVELING $50	TOTAL PER DIEM	SHOP RATE $10.25/HOUR
				–	APRIL	–								
BAKER	EO	10	10	0	10	10	10	10	60	–	70	–	70	
JONES	IE	10	10	0	10	10	10	10	60	–	70	–	70	
SMITH	ST	10	10	0	10	X	X	X	30	80	40	50	90	DEPARTED 13APR
								TOTAL	150	$80			$230	
TRAINING:														
JOHNSON		10	10	0	10	10	10	10	60	N/A	N/A	N/A	N/A	
								TNG TOTAL	60					
														LABOR COST:
														150 HRS X $10.25
														= $1537.50

Figure 8. Personnel Log

book. Personnel holding a 3 skill level are considered as being in training; however, other personnel can be assigned to the project for training purposes (4:33). The operations section will identify all personnel assigned to your project for training purposes.

At the end of each week, the log should be closed out. Closing out the personnel log consists of determining the cost of travel, per diem, and labor for the week.

To determine travel costs for the week, enter the one way transportation cost in the travel column for any personnel that arrived or departed during the week. Personnel in training status are considered as an unfunded cost, so there will be no travel costs associated with the movement of personnel in this category. Total travel cost for the week equals the sum of the figures in the travel column.

Per diem costs for each individual are calculated by multiplying the appropriate per diem rate by the number of days the person was assigned to the project during the week. The per diem cost for each individual should be recorded in the per diem column of the log book. In some cases, you may have to allow for extra per diem that personnel may be entitled to while traveling to or from the project location. You should check with the finance office to determine the correct per diem rate to use during travel days. Per diem costs for personnel in training status are not charged against the funded cost of the project. The total per diem

cost for the week equals the sum of the figures in the per diem column.

Labor costs are calculated by multiplying the total man-hours used during the week by the current shop rate. The operations section will provide you with the shop rate to use for your project. Training hours are not included in the calculation for labor costs. Training hours and costs are reported separately from labor costs.

Material Log. A material log should be established to track any materials that are billed to the project when the materials are delivered. Some examples of this type of material would be ready mixed concrete or hot mixed asphalt. You should keep a log listing daily deliveries, and maintain a running total of the amount of material remaining to be delivered under the terms of the contract.

At the end of each week, the cost of the materials received is calculated by multiplying the unit cost of each material by the amount delivered during the week. To determine total material costs, this figure must be added to the cost of materials ordered by the planning or material control sections through regular supply channels.

Fuel Log. The fuel log is used for keeping a record of fuel usage. The fuel log should have different sections for diesel and gasoline. Each time a vehicle or piece of equipment is refueled, the operator should report the quantity of fuel obtained. One way to collect fuel receipts is to place a box in the field office or other convenient

location and have the operators deposit their receipts after refueling. Fuel receipts should be collected each day, and the total amount of diesel fuel and gasoline obtained during the day should be entered in the fuel log.

The fuel log should be closed out weekly. Weekly fuel costs are determined by multiplying the amount of fuel obtained by the current price of fuel. The operations section will provide you with the correct prices to use for diesel fuel and gasoline.

Rental Equipment Log. A rental equipment log is maintained in order to track costs associated with any equipment that is rented. Rental costs are calculated based on the terms of each contract.

Equipment Log. An equipment log is used to keep records on vehicles and equipment assigned to your project. To set up the log, list the vehicle registration numbers down the left side of the page. Columns headings for weekly hour and mileage readings should be listed across the the top of the page. An equipment log is shown in Figure 9.

At the beginning of the project, an individual should be tasked with the responsibility of obtaining mileage or hour readings for each vehicle at the end of each week. This information should be recorded in the equipment log. At the end of each week, vehicle usage for each vehicle is determined by subtracting last week's reading from the current week's reading.

WEEK 7 9-15 APRIL	REG #	MILES	HOURS	LAST READING	TOTAL (THIS WEEK)	DEPRECIATION RATE	TOTAL
PICKUP	6654	6650	—	6500	150	.50	75
BACKHOE	3790	—	1380	1360	20	2.50	50
						TOTAL	125

Figure 9. Equipment Log

Vehicle depreciation is calculated by multiplying vehicle usage by the depreciation rate for the particular piece of equipment. Depreciation rates for specific pieces of equipment are obtained from the operations section. Be sure that you are working with the proper units, for example depreciation rates for vehicles are usually based on miles driven, while depreciation rates for construction equipment are usually based on operational hours. Weekly depreciation cost is equal to the sum of all of the individual depreciation costs for the week. Vehicle depreciation is an unfunded cost.

Construction Diary. You should maintain a daily diary of important events. Typical entries in the diary should include weather conditions, problems encountered, work accomplished, meetings held, agreements reached, and any other information that may be valuable at a later date.

Project Status Report.

AFR 93-9 requires that project costs be reported weekly (4:33). Usually, cost information and construction progress information are combined into one weekly project status report. Costs and construction progress should be reported following the format prescribed by your unit.

Completing the Project

When your project is completed, you must complete a DD Form 1354, Transfer and Acceptance of Military Real Property. This form is used to document the final cost of the project, and to transfer the completed work to the host base civil engineering squadron. Information necessary to complete the form is obtained from the DD Form 1391 and your cost accounting records.

Before signing the DD Form 1354, the host base will conduct a final inspection of the work performed. Any construction deficiencies found during the inspection will be noted on the reverse side of the form. All deficiencies must be corrected before your project is considered complete. Be sure to save a copy of the signed DD Form 1354 for RED HORSE records.

XIV. Material Control

Introduction

This section discusses some of the steps that a construction manager can take to insure that construction materials are properly controlled during a construction project.

Preconstruction Material Control

One of the first things that a construction manager should do is establish a good working relationship with the planning section. The planning section develops the bill of materials that will be used to order the materials for your project. A good working relationship with the planning section is necessary because in many cases, the planners can not order the proper materials without knowing the construction methods that will be used or the size and type of tools and equipment that will be used on the project.

A typical example of this would be materials required for concrete formwork. The type and quantity of materials ordered for concrete formwork depends on how many wooden forms will be built on the job site, and whether or not any reusable metal forms will be used. A planner will have no idea of your requirements unless you discuss your needs with him.

Another consideration is that not all of the materials necessary to complete your project will be shown on the drawings. For example, concrete formwork for small

foundations and ground floor slabs are usually not shown on the construction drawings, and materials required for these forms can easily be overlooked. Temporary bracing, shoring, nails, and bolts for fastening small pieces of equipment to a structure are examples of other types of materials not always shown on the drawings.

It is to your advantage to identify and resolve any material problems before you begin work. One way to avoid material problems is to check the bill of materials against the quantity survey that you developed while working on the project schedule. For example, if one of your work elements is installing 3000 square feet of ceiling tile, then you should check the bill of materials to insure this amount of ceiling tile, plus an allowance for waste, is on order.

If there is a significant difference between your quantity survey and the bill of materials, you should discuss the discrepancy with the planning section in order determine the correct quantity required. In some cases, the discrepancy may be the result of ambiguous drawings that do not clearly indicate the scope of work involved. If this is the case, you should contact the project manager for clarification.

Job Site Material Control

Once construction begins, close control of your material inventory is essential. On some large projects, supply personnel may be assigned to the project to assist with the

management of materials. On other projects, management of materials rests solely with the construction manager.

One of your major concerns will be material storage. You should pay particular attention to the way materials are stored because materials are often ruined by improper storage methods. You will probably be involved with a variety of materials, some of which will require indoor storage. The host base project officer should be your initial point of contact for obtaining covered storage areas. Material storage areas on the project site should be located where they will not interfere with work but be readily accessible to the workers.

One way to control materials during construction is to maintain a material inventory which should be updated daily to reflect the current amount of each material on hand. A properly maintained material inventory will help you anticipate material shortages. In many cases, if a construction manager does not control his material inventory, needed materials are not ordered until the existing supply is exhausted, resulting in a project delay. For example, if you are constructing a wood frame building and have used 40% of your nails, but have only completed 20% of the framing, you should order additional nails immediately. Anticipating a shortage and ordering extra materials early enough should avert a work stoppage due to lack of materials.

Whenever the materials ordered for your project are not available in sufficient quantity to complete the work, you should investigate the reason why. In some cases the reason may be that not enough allowance was made to allow for cutting or other legitimate losses. If this is the case, you should make a note of the actual allowance rate appropriate for the work involved, and use this rate on future projects.

Often, material shortages are the result of carelessness. This is often a result of workers not properly securing tools and materials at the end of the day, or workers who are wasteful because an abundant supply of material seems to be on hand. If this is the problem, then you should firmly remind the workers and their team leaders of their responsibilities concerning the proper use and care of materials and equipment.

XV. Construction Methods and Quality Control

Introduction

This section pertains to work performed on the job site, including construction techniques and construction quality control. This section is not intended to be comprehensive or cover information from all trades. Rather, it is intended to cover topics of a general nature that need to be emphasised.

Construction Methods

As a construction manager, you will be directing and supervising workers from various construction trades. This is a difficult task, but proficiency comes through experience. You are not expected to be skilled in every trade; however, you should try to obtain a good working knowledge of the basics of various trades as you gain experience as a construction manager.

A good way to obtain a basic working knowledge of different construction methods is to observe experienced craftsmen on the job and discuss with them the basics of the construction techniques inherent in their particular trade. As you gain experience you will find that some construction techniques produce better results than others. Also, you will find that every project is unique; a particular technique that worked well in one situation may not be the best method to use under different circumstances.

Supervising a construction crew is a difficult job. The following sections discuss some construction techniques that should help you avoid some common technical mistakes.

Checking Key Dimensions. All key elevations and measurements should be checked and double checked as work progresses. A construction manager should make a final check of certain key measurements personally before allowing construction to continue past a certain point. For example, it would be appropriate for a construction manager to perform a final check of a foundation anchor bolt layout before allowing concrete to be placed. Be sure to compare diagonal measurements between bolts on opposite sides of the structure to insure that the bolt pattern is laid out square. Other examples of key items you should check include equipment center lines, building column lines, floor elevations, road and runway center lines, key grade stake elevations, and other important lines or points used as references for other measurements.

Batter Boards. Batter boards are used to establish horizontal and vertical reference points on building projects. Batter boards are established by the site development section, and can be established to represent any reference line that you choose to work from. Typical reference lines commonly used are the center lines of columns or anchor bolts; however, many other reference lines are also frequently used depending on the work being performed.

You should coordinate your batter board requirements closely with the site development section so that they know what reference lines you require. If your crew does not include a RED HORSE site developer, site development support is available from the host base civil engineering squadron. Once the reference lines are established, be sure that every member of your crew knows what the lines represent.

Batter boards should be located at least ten feet from the building lines. This will allow enough room for foundation excavations to be completed without disturbing the batter boards.

Foundation Excavations. All excavations for buildings or other large structures on which concrete forms will be used should be excavated wide enough to allow workmen ample room to set and properly brace the forms. A minimum of four feet of work space should be allowed on each side of the form for this purpose. For example, if you are building a foundation wall 12 inches thick, your excavation should be a minimum of nine feet wide. If you are building a floor slab with a thickened edge, and will use only an outside edge form, the excavation should extend at least four feet outside the concrete line around the entire slab. A common way to mark the limits of an excavation is to mark the boundaries of the excavation on the ground with lime. This provides the equipment operators with a good reference to follow while excavating.

Footings and small slabs on grade do not normally require this amount of work space; however, do not permit any craftsman to set or brace a concrete form over 12 inches high without allowing at least the minimum required clearances stated above. Concrete forms that are not properly braced will either collapse or move out of alignment.

One improper construction technique often used with concrete formwork is to make a narrow excavation, and try to supplement improper bracing of the forms by backfilling between the forms and excavation with rock or soil. Under no circumstances should you allow this method to be used on your project. This method will not properly hold the forms in line, and requires additional excavation work to remove the forms.

Reinforcing Steel. Reinforcing steel should be placed as close as possible to the locations shown on the drawings. In some cases, minor variations are allowable around embedments; however, no major deviations are allowed without the approval of an engineer.

It is important to maintain the clearances between the steel and the earth or face of the forms as shown in the drawings. Plastic spacers or nails can be used to maintain proper clearance between the reinforcing steel and the concrete forms.

If metal chairs are used to support the steel off the ground, be sure that they are sturdy enough to support the

steel during placement of the concrete. One common problem with metal support chairs is that many types will collapse or allow the reinforcing steel to shift under lateral pressure.

One satisfactory method of supporting reinforcing steel off the ground is to manufacture on site, small concrete blocks about the size of common bricks, with a thickness of three inches. These blocks will provide a good solid base for the reinforcing steel.

Under no circumstances allow reinforcing steel to be placed on rocks, bricks, chunks of broken concrete, or any material that will not firmly support the steel. Rocks and chunks of broken concrete are unsatisfactory because they are seldom the right height and do not provide a firm base. Bricks are not acceptable because they are not as strong as the concrete they will be imbedded in.

Be sure that the spacers or blocks are placed properly to obtain the clearance specified in the drawings. Reinforcing steel usually runs in two directions, one layer on top of the other. In order to maintain the proper clearances, be sure that the spacers or blocks are placed against the outermost layer of reinforcing steel, otherwise you will not have the proper clearance between the reinforcing steel and the concrete forms or ground.

Reinforcing steel with light rust is acceptable for use; however, if the rust is heavy or flaking, the steel should not be used. The best way to determine whether or not to

use the steel is to firmly grab the bar and rotate your hand slightly. If the rust comes off in your hand, do not permit the steel to be used. Loose flakey rust will prevent the concrete from properly bonding to the steel.

Be sure that concrete forms are oiled before the reinforcing steel is in place. This is just common sense, but quite frequently oiling the forms will be forgotten, and a worker will attempt to rectify the situation by oiling the forms with the steel in place. Any oil on the reinforcing steel will prevent a proper bond with the concrete; therefore, any steel contaminated with oil must, be removed and replaced.

Whenever reinforcing steel is bent, it should be cold bent. Do not allow reinforcing steel to be heated in order to facilitate bending. Overheating reinforcing steel will significantly reduce its strength.

When tieing reinforcing steel mats or cages, it is not necessary to tie every intersection unless this is called for in the drawings or specifications. Under normal circumstances, the reinforcing steel needs to be tied only in enough places to insure that it is well secured and will not be displaced during concrete placement.

Tack welding reinforcing steel to hold it in place is not permitted because tack welds significantly reduce the strength of the steel.

Concrete Placement. Before ordering concrete, you should check to insure that all concrete forms are properly

braced, at the correct elevation, anchor bolts are in their proper position, and your crew has all the required tools and equipment ready.

Concrete should be placed at the slump called for in the drawings or specifications. Slump refers to the workability of the concrete and is measured by a test performed by the site development section. Typical slumps used in concrete construction range between two and five inches; however, other slumps may be specified.

There is a general tendency for craftsmen to want increase the slump of the concrete by adding water to it. This makes the concrete easier to work, but significantly lowers the strength and durability of the concrete. Do not permit any craftsman to add water to concrete that is already at the proper consistency.

Vibrating Concrete. Electrical or pneumatic vibrators are normally used to consolidate concrete after it is placed in the forms. When vibrating concrete, the vibrator should be inserted and removed from the concrete vertically, straight in and straight out.

Do not allow the vibrator to be used to move concrete horizontally within the forms. Misusing a vibrator to move concrete will result in aggregate segregation and the formation of weak planes within the concrete mass. Over vibrating concrete will also result in segregation and weak planes.

Finishing Concrete. Finishing concrete takes special skills and precautions. Do not permit workers to add water to the concrete surface while troweling the concrete. Finishing concrete is hard physical work, and some workers will try to make the job easier by sprinkling water on the surface of the concrete while floating or troweling the concrete. This ruins the surface of the concrete by increasing the water cement ratio on the surface of the concrete, resulting in the formation of a weak layer of concrete near the surface of the slab. This results in surface scaling or cracking within a short period of time.

If a broom finish is called for on the drawings, do not allow the broom finish to be applied until after the concrete has been properly floated. Many workers tend to apply a broom finish without floating the concrete because there is a misconception that a broom finish will cover up surface irregularities. This is not true, and allowing this so-called short cut to be used will result in a substandard concrete surface. Proper floating of concrete is always necessary prior to troweling or applying a broom finish.

Contraction joints are used to control shrinkage cracking which occurs as concrete cures. Contraction joints are used in concrete slabs on grade to insure that cracking occurs at the joint location rather than at random locations. If the drawings do not specify the location of contraction joints, you, or your craftsmen will have to lay them out. Try to lay out the joints to divide the slab into

squares if possible. If squares are not possible, keep the length to width ratio of each section under 1 1/2:1. Sections that exceed this ratio will tend to crack between the contraction joints. As a general rule for large slabs, contraction joints are usually spaced between 10 and 15 feet apart.

Whenever contraction joints are cut or formed in a concrete slab, be sure that the depth of the joint is at least 25% of the depth of the slab. For Example, if the concrete slab is eight inches deep, the contraction joint should be at least two inches deep in order to insure that the concrete will crack at the contraction joint.

Buried Utilities. Before starting any excavation or trenching work, you must have an approved AF Form 103, Construction Permit. Arrangements should be made in advance to have any existing buried utilities staked out before you start digging. Once the utilities have been marked on the ground, you should insure that your entire crew is familiar with their locations.

Before digging in the area of known utilities, the buried utilities should first be physically located. This should be done by hand, with shovels. Do not allow machinery such as backhoes or trenchers to be used to locate utilities. The only correct way to physically locate a utility line is by hand. This requires time and effort, but it is necessary to avoid damaging the utility line. Extreme

care must be used when locating utilities because even shovels can damage cable insulation or pipe coatings.

Once the utility is physically located and marked, trenching or excavation work can begin; however, under no circumstances should you permit machinery to dig within four feet of the known location of the utility line. The soil in this area must be excavated by hand to properly safeguard the utility line. Whenever machinery is digging near any known utilities, a spotter should be used to insure that the utilities are not hit.

The reason for maintaining a four foot clearance is both to protect the workers and the utility lines. Cutting a high voltage power line, a fuel line, or a natural gas line could have disastrous consequences. Also, broken utility lines could take days to repair.

Do not be misled by equipment operators who tell you that they can excavate right up to a utility line without damaging it. This is virtually impossible even for highly experienced operators. Often, operators will hit a utility, but believe they did not damage it. For example, if a communications line is pulled even slightly by the bucket of a backhoe, it may appear that no damage is done; however, the line may have broken several feet away and the break will not be visible. A small nick or cut in the insulation of electrical lines will seriously damage the cable. Buried pipelines often have protective coatings that can be easily damaged.

Backfilling Trenches. If the plans or specifications call for trenches to be backfilled and compacted in six inch lifts, then this is the way it must be done, no exceptions. One incorrect method often used is to backfill the entire trench in one lift, then run a loader or bulldozer over the trench to compact the fill. This is not a suitable substitute for backfilling and compacting in six inch lifts and will result in excessive settlement which is not acceptable under pavements or foundations.

If the drawings or specification do not specify how the trench should be backfilled, use your own judgement to decide on an appropriate method. In many cases, if no particular method is specified, backfilling the entire trench at one time may be an acceptable method if the backfill is left a little high to allow for settlement.

Field Changes. All field changes should be approved by the project manager or the design engineer. Sometimes what appears to be a minor change to the plans or specifications could significantly reduce the load bearing capacity of a structural member. Other changes could affect the layout of equipment in the finished facility or cause interference with other items.

As Built Drawings. As built drawings are maintained as a record of the way a project is actually built. Any field changes made during construction should be recorded on the as built drawings. Normally, one set of project drawings is set aside and maintained specifically for this purpose. As

built drawings should be updated each time a field change is made. When the project is complete, the as built drawings should be turned in to the project manager.

Public Relations with the Host Base. During construction, you should maintain good relations with the host base. Some of the things that you can do to maintain good relations with the base include timely coordination of host base support and maintaining a neat and orderly job site. Usually construction managers that complain that the host base treats them as unwelcome guests violate these two simple rules.

If you properly manage your project and coordinate necessary support in a timely manner, you should have little trouble obtaining host base support. On the other hand, if because of poor planning, you consistently request support on an emergency basis, you will soon loose credibility and find it difficult to obtain timely support even for legitimate short notice requests.

Typically, problems occur when a construction manager constantly runs out of materials, or when workers cut utility lines that are clearly shown on the construction permit and staked out on the ground. These types of things are certainly expected to occur to some extent on any construction job, but when they begin occurring on a frequent basis, you can expect the host base to become irritated with the presence of a RED HORSE team.

Keeping your job site neat and orderly reflects well on you and your crew. In addition to keeping the job site clean, you should also consider how your project affects the surrounding area. For example, if your equipment tracks mud on a base road, you should dispatch a crew to clean the road rather than leaving it for others to do.

Construction Quality Control

Construction quality control involves insuring that work in progress is in compliance with the plans and specifications. There are usually two types of quality control performed on most construction projects, quality control of materials and quality control of work in progress.

Quality control of materials involves testing materials to insure that they meet the specifications. Materials that are routinely tested include aggregates, concrete, asphalt, and compacted soils or base courses. The site development section is responsible for material testing on a project.

Quality control of work in progress is a responsibility of the construction manager. You should constantly monitor all work to insure that work in progress meets the plans and specifications, and that the finished product will meet acceptable finished quality standards. By closely monitoring work in progress, you should be able to discover and correct deficiencies at an early stage.

One mistake commonly made by construction managers is to accept poor quality workmanship rather than to have the work redone properly. This should be avoided because the finished project will be a reflection of the pride and workmanship that went into the project. Some of the most common causes of poor quality work are:

Inadequate Information. In some cases, poor quality work may result from incomplete or unclear drawings. If this is the case, you should seek clarification from the project manager or design engineer.

In many cases, poor quality work results when adequate information is available, but workers choose not to use it. This usually results when workers feel that they know enough about the job that they do not need to refer to the project drawings. This usually results in costly errors and an excessive amount of rework. Be sure that your lead craftsman or work leaders have a set of drawings available in their work area, and use them.

Poor Communication. When making job assignments, construction managers and work leaders should give clear instructions to the construction crew. You should insure that each crew knows exactly what their task is, how it is to be performed, and the time and resources available to accomplish the task. Before dispatching a crew, you should insure that they fully understand their work assignment.

Lack of Standards and Inspections. Poor quality work often results from a construction manager's failure to

establish quality standards and convey the standards to the crew. If job standards are not established, the quality of work produced often begins to deteriorate. This trend usually starts when a when a construction manager consistently accepts low quality work. Once this trend is established, your construction crew may interpret the inferior work that you accepted as the standard of quality that you expect, and they will produce accordingly. Typically this results in the quality of work continuing to deteriorate throughout the life of the project. There are exceptions to this rule, some craftsmen will produce extremely high quality work regardless of the low standards that might be acceptable to a poor construction manager, but in general, if you do not set and enforce high quality standards, the quality of work produced on your project will be substandard.

You can easily avoid this problem by setting high standards, making these standards known to the crew, and accepting nothing less. If you set high quality standards, and the crew knows what these standards are, they will typically strive to exceed your quality expectations.

During construction, you should closely monitor all work in progress to insure that it is being performed properly. In many cases, mistakes or poor quality work can be discovered and corrected before they develop into serious problems. Sometimes this requires that an entire section of work be torn down and started over. This is a difficult

decision to make and requires a great deal of thought on the part of the construction manager.

One common mistake made by construction managers is to try to avoid starting anything over. If the completed work can be salvaged by making some corrections and adjustments, this is certainly a good solution. However, in some cases the best solution to the problem may be to tear out the entire section of faulty work and start over. When making this type of decision, you should consider how the faulty section of work will affect other portions of the project. If the inferior work will significantly affect other portions of the project, you can easily spend more time trying to "make it work" than if you had just started over when the mistake was first discovered.

Inspecting work should be a continuous process. Try to look at all work areas every day, do not wait until a significant portion of work is accomplished and then inform the crew that it is wrong or unacceptable.

When inspecting work you should question anything that does not look right. A competent craftsman will check the work and correct it if necessary or confirm that it is correct as is. You should be on guard against workers who give the standard reply of "I have been doing this type of work for 10 years and this is the way I have always done it." If the work is obviously wrong, do not hesitate to inform the worker that he has been doing it wrong for the past 10 years.

You should never allow any excavation or trench to be backfilled unless you, or someone to whom you have delegated the authority, inspects and approves the work that was done in the excavated area. Be sure that your crew knows and understands this policy. If a crew disregards your instructions and backfills an excavation prior to having the work inspected, have them remove the backfill so that the work can be properly inspected.

Defective or Inadequate Equipment. If you do not have the proper equipment available to properly accomplish the job, this may be a result of an oversight during project planning. You should make every effort to obtain the proper equipment as soon as possible. Sometimes, you may have to use what is available and do the best you can; however, you should try not to make the same mistake when planning your next project.

Sometimes proper equipment is not available due to mechanical failures. You should insure that all equipment is inspected and serviced regularly while assigned to your project. A common mistake made by some construction managers is that they do not allow equipment operators sufficient time to inspect and service their equipment during the work day.

Workers Having Insufficient Skills. You should be knowledgable of the skills and abilities of your crew. You should take the skill and experience level of the workers into consideration when making work assignments. Do not

assign workers to tasks that may be inappropriate for their skill level unless they will be supervised by an experienced craftsman (24:Sec 8,6).

XVI. Personnel Management

Introduction

In addition to the knowledge required to plan and execute a construction project, a construction manager must have the ability to lead and motivate workers, and to effectively deal with workers personal problems. This section covers some of the basics of leadership, motivation, and human relations.

Leadership

Some common leadership traits associated with successful construction managers are:

Job Knowledge. In order to guide your construction project to a successful completion, you must have a good overall knowledge of the work involved. Workers will quickly loose confidence in a construction manager who has little job knowledge. A lack of job knowledge usually results in a construction manager being confused, indecisive, and unable to handle the day to day problems associated with construction activities.

Knowledge of Your People. You should have a good knowledge of the capabilities and abilities of your crew. The only way to fully satisfy yourself with the capabilities of a worker is through personal observation. In all probability, you will be unfamiliar with many of the workers that will be assigned to your project, so it will take some time before you can form your own personal opinion on the

abilities of each individual crew member. Most of the workers assigned to your project will have some type of reputation in the squadron. You can talk to other construction managers to get their opinion, but remember, you should form your own opinion based on the persons job performance for you.

Sense of Responsibility. As a construction manager, you must be willing to accept full responsibility for your decisions and actions. Remember that you can delegate portions of your authority to your crew leaders, but the ultimate responsibility for the successful completion of the project remains with you.

Firmness and Fairness. Consistency is necessary whenever enforcing or interpreting rules or work standards. If you are indecisive, or fail to act consistently, your crew will become confused because they will not know what you want or expect. Inconsistent enforcement of rules and policies could result in creating a perception that favoritism is being shown to certain members of the crew. This perception of favoritism, whether real or imagined, could result in serious morale and discipline problems.

Expressiveness. Effective communication is essential to getting the job done. In addition to clearly expressing your orders and directions, you must insure that they are understood. One way to insure that your orders or directions are understood is to ask the worker to repeat them to you in his own words.

Concern for Personnel. As a construction manager, you are responsible for the morale and welfare of your crew. Nearly every personal problem that arises among your crew will be brought to your attention. You will be amazed by quantity and types of personal problems that can arise during a deployment.

In general, when a worker approaches you with a personal problem you should analyze the problem and take the necessary action to help resolve it. Most problems can be resolved on the spot or by making a few telephone calls. Serious problems may require the person to return home. In this case, you should coordinate your action through the operations section. In any event, do not hesitate to ask the operations section or the first sergeant for help with resolving personal problems.

You should also be aware that not everyone with a problem will approach you with it. You can usually identify personnel in this category whenever there is a drastic change in an individuals morale or job performance for no apparent reason. In this situation you will have to approach the worker in order to find out the details of any problems he may be facing.

Initiative, Persistence, and Enthusiasm. A construction manager who takes it upon himself to get things done without being told, who works hard to get things done properly, and who maintains and projects a positive attitude towards the job demonstrates these three characteristics of a good

leader. A construction manager that posses these characteristic usually has little trouble setting a good example and inspiring a crew to take pride in their work. This usually results in construction crew with high morale and esprit de corps (24:Sec 11,1-3).

Motivation

Many motivational problems on construction projects are the result of either poor leadership or poor planning. According to one study the most common demotivators on construction projects are:

1. Lack of materials.
2. Project confusion.
3. Communications breakdowns.
4. Rework.
5. Unavailability of tools and equipment.
6. Disrespectful treatment.
7. Lack of recognition.
8. Little participation in decision making.
9. Lack of cooperation among crafts.
10. Poorly trained foremen (21:1).

A construction manager has direct control over each of these ten demotivators. A person who possesses good leadership characteristics and who has done an adequate job of planning and organizing the construction effort should have a solid foundation for developing a highly motivated work force.

XVII. Conclusions and Recommendations

Chapter Overview

This chapter presents conclusions and recommendations based on the results of this research effort.

Research Objective One - Conclusions and Recommendations

Research objective one was to determine what types of formal construction manager's training programs currently exist within the Department of Defense. Conclusions and recommendations reached are as follows:

Conclusions:

1. There are no formal courses within the Air Force or DOD specifically designed to train craftsmen to assume the duties and responsibilities of RED HORSE construction managers. Some RED HORSE squadrons conduct their own training programs, but the frequency and depth of instruction varies depending on the personnel available to organize and direct the training.

2. Most construction management courses available within the DOD are directed towards contract management, rather than construction planning and supervision.

3. The U.S. Navy advanced courses, and the U.S. Army Construction Management and Construction Planning correspondence courses cover topics essential to successful construction management such as, planning, scheduling, construction methods, quality control, and construction supervision. Enrollment space in the Navy advanced courses

is limited; however, the Army correspondence courses are open to all DOD personnel.

4. The problems associated with craftsmen moving into first line supervisory positions are not unique to the Air Force, but are nearly identical to the problems encountered in the civilian construction industry. Current emphasis in the civilian construction industry is towards increased training for craftsmen moving into management positions.

5. There is a need for a construction manager's training program developed specifically to meet the needs of RED HORSE units.

Recommendations:

1. The Air Force should develop a formal construction manager's training course for noncommissioned officers assigned to RED HORSE units. The purpose of the course would be to prepare noncommissioned officers to assume the duties and responsibilities associated with RED HORSE construction management.

2. A limited number of RED HORSE noncommissioned officers should be selected each year to attend one of the Navy advanced courses. After completion of the course, the returning student should share the knowledge and information obtained with his unit.

3. All noncommissioned officers assigned to RED HORSE squadrons should be encouraged to enroll in the Construction Planning (course number EN0067) and Construction Management

(EN0375) correspondence courses available from the U.S. Army. Information is available from:

The Army Institute for Professional Development
U.S. Army Training Support Center
School Code 051
Newport News, VA 23628

Research Objective Two - Conclusions and Recommendations

Research objective two was to identify the most important tasks and responsibilities associated with RED HORSE construction management. Conclusions and recommendations are as follows:

Conclusions:

1. The tasks performed by RED HORSE construction managers are nearly identical to the tasks performed by construction managers in the civilian construction industry. Research conducted to accomplish this objective determined that of twenty-two tasks commonly associated with civilian construction management, nineteen of the tasks were applicable to RED HORSE construction management.

2. Twenty-two construction management tasks were identified as being applicable to RED HORSE construction management. Three additional tasks were added to the basic list of nineteen tasks to complete the final list.

3. A basic knowledge of, and some skill in each of the twenty-two identified tasks is essential to successful RED HORSE construction management.

Recommendations:

1. The basic list of twenty-two RED HORSE construction management tasks should be used as the starting point for developing a formal RED HORSE construction manager's training program tailored specifically to the needs of RED HORSE units.

2. All RED HORSE noncommissioned officers should receive training in each of the twenty-two tasks before being assigned as construction managers.

Research Objective Three - Conclusions and Recommendations

Research objective three was to develop a RED HORSE construction manager's handbook incorporating the construction management tasks identified by research objective two. Conclusions and recommendations are as follows:

Conclusions:

1. RED HORSE construction manager's handbooks currently in use contain mostly policy letters and checklists. Although these handbooks contain a lot of valuable reference information, they need to be supplemented with additional construction management information.

2. There is a need for a construction manager's handbook which provides detailed information on how to prepare for, and carry out the duties and responsibilities associated with RED HORSE construction management.

3. It was possible to address each of the twenty-two RED HORSE construction management tasks in a handbook. In some cases, similar tasks were combined and addressed together. The handbook addresses topics applicable throughout the life of a project, from preconstruction planning to project completion.

Recommendations:

1. Every noncommissioned officer assigned to a RED HORSE squadron should receive a copy of the handbook developed during this study.

2. Each RED HORSE squadron should supplement the handbook by adding information pertaining to local policies and procedures.

3. Construction manager training programs conducted by individual RED HORSE squadrons should use the handbook as a course guide.

Recommendations for Further Study

Two recommendations for further study are presented:

1. A supplement to the handbook should be developed to cover construction techniques and quality control procedures. The supplement should cover the civil, mechanical and electrical trades in depth. The purpose of this supplement would be to provide a construction manager with information concerning construction skills that may be outside of his own career specialty.

2. A formal RED HORSE construction manager's training course should be developed to meet the specific needs of RED HORSE. The twenty-two tasks identified as important RED HORSE construction management tasks should be used as a starting point for developing the course content.

Appendix A: Organization and Manning of RED HORSE Squadrons

Mission of RED HORSE

Air Force Regulation 93-9, Civil Engineering RED HORSE Squadrons, states that the mission of RED HORSE is to "support the Air Force Civil Engineering Wartime mission (4:6)." In order to accomplish this mission, paragraph 1-2 of AFR 93-9 states that a RED HORSE Squadron:

> a. Performs heavy damage repair required for recovery of critical Air Force facilities and utility systems required for aircraft launch and recovery that have been subjected to enemy attack or to national disaster.
>
> b. Accomplishes required engineering support necessary for the beddown of weapons systems, and the installation of critical utility and support systems required to initiate and sustain operations, especially in austere, bare base environments.
>
> c. Provides, in peacetime, an engineering response force that can support special operations such as an aircraft crash or nuclear weapon accident recovery in remote areas or can operate contingency airfields or operating locations required by JCS missions.
>
> d. Is manned, equipped and trained to conduct heavy engineering operations as independent self-sustaining units (with resupply of consumables) in remote hostile locations (4:6).

Objectives of the RED HORSE Program

According to AFR 93-9, The primary objectives of the RED HORSE program are to:

> a. Develop and maintain a highly skilled, mobile, self-sufficient Air Force combat engineering force capable of rapid response and independent operations to support contingency operations worldwide.
>
> b. Provide supplementary training to make sure that Air Force RED HORSE military personnel are able to perform direct combat support tasks including unique engineering capabilities maintained only by RED HORSE units (4-6).

Special Capabilities

In addition to the heavy construction and repair capability of RED HORSE, the following special engineering capabilities are maintained by all RED HORSE squadrons:

1. Airfield lighting installation.
2. Communications.
3. Concrete mobile operations.
4. Explosive demolition operation.
5. Expedient airfield arresting barrier installation.
6. Materials testing.
7. Quarry operations.
8. Rapid runway repair.
9. Revetment erection.
10. Water well drilling.
11. Disaster preparedness mobility team.
12. Bare Base installation (4:10).

Organization of RED HORSE Squadrons

RED HORSE Squadrons are organized into four branches and a special staff (4:16). The major duties and responsibilities of each section are as follows:

Command Section. The command section directs and controls the mission accomplishment of the squadron.

Special Staff. The special staff consists of the following four sections:

1. Funds Management - The funds management section manages the squadron's budget.

2. Training - The training section develops and monitors RED HORSE training programs.

3. Safety - The safety section develops and monitors the squadron safety program.

4. Unit Mobility Center - When activated, the unit mobility center monitors and coordinates RED HORSE deployments.

Administrative Branch. The administrative branch handles the administrative functions of the squadron, including discipline, official correspondence, and management of the orderly room.

Engineering Branch. The engineering branch is responsible for engineering designs, plans and specifications, cost estimates, project management services, construction surveying, and quality control testing.

Operations Branch. The operations branch is responsible for the actual accomplishment of all RED HORSE construction projects. The operations branch consists of three main sections:

1. Operations Center - The operations center monitors the progress of all construction projects, coordinates deployment support, and operates the squadron communications center.

2. Cantonment Flight - The cantonment flight is responsible for vertical building construction and the

installation/operation of various utilities necessary for the operation of an air base. The cantonment section also has the capability to provide electrical power, potable water production, and sewage disposal under field conditions (4:18). The cantonment flight consists of the following sections, each composed of personnel with similar career fields, who are trained and equipped to perform specialized tasks:

A. Metal and welding.

B. Carpentry.

C. Masonry.

D. Plumbing.

E. Electrical.

F. Power production.

G. Heating, refrigeration, and air conditioning.

H. Sanitation.

I. Water and waste.

J. Entomology (4:18).

3. Airfield Flight - The airfield flight is responsible for horizontal construction, pavement, and heavy construction including runway construction and repair, roads, earthmoving, water well drilling, and explosive demolition operations. The airfield flight consists of two sections:

A. Pavement section.

B. Equipment section.

Logistics Branch. The logistics branch consists of five main sections:

1. Logistics Plans - The logistics plans section is responsible for the squadron mobility plan, which "contains detailed instructions for deploying squadron personnel and equipment (4:20)." The logistics plans section also plans and coordinates the movement of construction equipment and materials to RED HORSE project sites.

2. Vehicle Maintenance Section. "The primary purpose of the vehicle maintenance section is to support operations of vehicles and equipment assigned to the RED HORSE Squadron (9:20)."

3. Supply Section. The supply section orders, receives, and stores materials required for RED HORSE projects. The supply section is also responsible for weapons storage.

4. Services Section. The services section establishes and operates field messing facilities when the squadron is "TDY or deployed to an area where food service facilities are not available (4:18)." The services section also provides mortuary services and operates field laundries when necessary.

5. Medical Section. The medical section provides "medical support for PED HORSE squadron personnel operating in the field or at isolated locations during contingency situations (4:20)."

RED HORSE Manning

Personnel assigned to RED HORSE units are drawn from civil engineering, logistics, supply, vehicle maintenance, medical, services, administrative and other career fields.

Because of the wartime mission of RED HORSE, specific guidelines have been established to insure that assigned personnel are capable of performing their assigned duties. AFR 93-9 provides the following guidance concerning RED HORSE assignments:

> RED HORSE echelons by virtue of their wartime mission, are deployable to forward or remote theaters of operation as independent operating units in potentially hostile environments. They are trained, equipped, and tasked to provide their own security and work under strenuous field conditions, including convoy operations, for extended periods of time. Theater taskings and standard RED HORSE operating policies require incremental units of RED HORSE personnel to deploy through and work at remote construction sites in unfriendly territory without benefit of external security protection. Such conditions subject RED HORSE personnel to an extraordinarily high probability of exposure to hostile fire and capture. These mission requirements dictate that all RED HORSE personnel must be world-wide deployable, fit to perform the full range of physical requirements of their assigned speciality, and qualified to bear arms. Therefore, personnel in the following categories are not assigned to RED HORSE:
>
> 1. Medically not qualified for worldwide mobility or to perform the physical requirements of their assigned specialties.
>
> 2. Not qualified to be armed and trained according to AFR 125-26.
>
> 3. Female personnel (4-11).

Appendix B: Work Element Checklist (8:Sec C,1-3)

BUILDINGS

_____ Remove existing structures
_____ Clearing and grubbing
_____ Layout
_____ Blasting
_____ Grading
_____ Fill, place and compact
_____ Landscaping, seeding and sodding
_____ Excavation and backfill
_____ Relocate existing utilities
_____ Concrete foundations and footings
_____ Pipe sleeves
_____ Under floor conduit and plumbing
_____ Transformer vault
_____ Grade beams
_____ Ground floor slab
_____ Anchor bolts or bearing plates
_____ Concrete columns, beams, girders
_____ Concrete floor and roof slabs
_____ Precast wall and roof panels
_____ Precast structural members
_____ Precast sills an lintels
_____ Concrete canopy and entrances
_____ Treads and nosings
_____ Pipe sleeve openings
_____ Structural steel
_____ Masonry - Concrete block, brick, structural tile
_____ Flashing
_____ Framing floors, walls, roofs, stairs
_____ Subflooring
_____ Door bucks and frames - wood
_____ Door bucks and frames - metal
_____ Overhead doors
_____ Window frames
_____ Conduit in slabs and walls
_____ Piping in walls
_____ Electrical rough-in
_____ Plumbing rough-in
_____ Siding - wood
_____ Metal siding and roofing
_____ Hoods and ventilators
_____ Insulation, roof
_____ Roofing
_____ Asphalt or wood shingles
_____ Ductwork
_____ Intercom system
_____ Telephone switchboard equipment
_____ Alarm systems, burglar, fire

_____ Electric service
_____ Telephone service
_____ Wallboard
_____ Lathing
_____ Stairways
_____ Metal studs and partitions
_____ Insulation, walls and ceilings
_____ Downspouts and gutters
_____ Fire escape
_____ Ladders
_____ Platforms and catwalks
_____ Roof scuttles
_____ Exterior doors
_____ Screen doors
_____ Windows
_____ Window screens
_____ Jalousies
_____ Exterior trim
_____ Glazing
_____ Louvers
_____ Cabinets
_____ Closet units
_____ Lockers
_____ Bulletin boards
_____ Mirrors and medicine cabinets
_____ Paneling
_____ Interior doors
_____ Metal doors
_____ Metal toilet partitions
_____ Security grills
_____ Plastering
_____ Ceramic tile
_____ Electric fixtures
_____ Plumbing fixtures
_____ Finish flooring
_____ Tile flooring, asphalt, rubber, vinyl, cork
_____ Acoustical tile
_____ Interior trim
_____ Handrails
_____ Calking
_____ Painting
_____ Curbs and walks
_____ Parking areas
_____ Fencing
_____ Cleanup
_____ Air conditioning
_____ Compressed air systems
_____ Dehumidifiers
_____ Dry cleaning equipment
_____ Exhaust fans
_____ Fire protection systems
_____ Generators
_____ Heating system

_____ Laundry equipment
_____ Pumps
_____ Refrigerators
_____ Shop equipment
_____ Ventilation equipment
_____ Mess equipment
_____ Water coolers
_____ Hospital equipment

OUTSIDE UTILITIES

_____ Clearing and grubbing
_____ Blasting
_____ Trenching and ditching
_____ Backfill and compact
_____ Erosion control
_____ Water mains
_____ Water service lines
_____ Sanitary sewer mains
_____ Sanitary sewer service lines
_____ Valves
_____ Valve boxes
_____ Manholes
_____ Water storage tanks
_____ Water pumps
_____ Sewage pumps
_____ Storm sewers and manholes
_____ Catch basins
_____ Culverts
_____ Culvert head and wingwalls
_____ Sewage treatment plants
_____ Poles
_____ Cable
_____ Transformers
_____ Telephone cable
_____ Underground duct
_____ Conduit risers
_____ Manholes and handholes
_____ Street lights
_____ Security lights
_____ Control devices
_____ Capacitors and voltage regulators

PLANT OPERATIONS

_____ Stripping quarry
_____ Drilling and blasting
_____ Handling and loading quarried material
_____ Hauling to crusher or job

_____ Setting up crusher plant
_____ Operating crusher
_____ Stockpiling crushed material
_____ Hauling crushed material to plants or job
_____ Setting up asphalt plant
_____ Operating asphalt plant
_____ Hauling asphalt to job
_____ Setting up concrete batch plant
_____ Hauling concrete to job
_____ Manufacturing concrete block - all sizes
_____ Manufacturing precast concrete units - all types
_____ Hauling precast units to job
_____ Reinforcing steel fabrication
_____ Prefabricating doors, windows, jalousies, louvers, frames
_____ Prefabricating stairs, cabinets, closet units
_____ Prefabricating concrete pipe

ROADS, PAVING, AND WALKS

_____ Clearing and grubbing
_____ Blasting
_____ Cut and fill
_____ Grading
_____ Trenching
_____ Move and change interfering utilities
_____ Culverts
_____ Heads and wingwalls
_____ Catch basins
_____ Storm drainage
_____ Prepare subgrade, subbase, base
_____ Fine grade
_____ Erosion control
_____ Asphalt prime coat
_____ Asphalt tack coat
_____ Spread and roll asphaltic concrete
_____ Spread and roll chip and gravel coats
_____ Concrete paving forms
_____ Reinforcing steel and dowels
_____ Expansion and contraction joints
_____ Finishing and curing
_____ Concrete curbs complete
_____ Concrete walks complete
_____ Asphalt curbs complete
_____ Asphalt erosion protection
_____ Asphalt walks complete
_____ Precast curbs installed
_____ Paint striping

Appendix C: Equipment and Tool Checklist (8:Sec D,1-5)

MASONRY

_____ Brick trowels
_____ Line and line holders
_____ Brick hammers
_____ Pointing trowels
_____ Mason's level (4 ft)
_____ Block saw & replacement blade
_____ Joint finishing tools
_____ Scaffolding
_____ Mortarboards
_____ Mixing bins or boxes
_____ Sand screens
_____ Mortar hoes
_____ Shovels
_____ Mortar mixer
_____ Pliers or side cutters
_____ Squares (framing)
_____ Rules (6 ft)
_____ Tapes (50 or 100 ft)
_____ Water hose or barrels
_____ Hoisting equipment
_____ Transportation equipment

CONCRETE WORK

_____ Square nose shovels
_____ Concrete rakes (not garden rakes)
_____ Come-along
_____ Screed board
_____ Vibrating screed
_____ Jitterbug
_____ Bull Float
_____ Darbies
_____ Edging tools
_____ Jointers or groovers
_____ Floats, wood, magnesium, rubber
_____ Trowels
_____ Fresno
_____ Power float
_____ Power trowel
_____ Vibrator (air-gas-electric)
_____ Concrete saw, with extra blades
_____ Concrete pump
_____ Heating equipment (cold weather)
_____ Curing material (curing compound, plastic film etc.)
_____ Curing equipment required

_____ Water hose
_____ Water pails
_____ Concrete mixer
_____ Transit mix trucks
_____ Batch plant
_____ Cement storage requirements
_____ Concrete paving machines
_____ Weighing devices
_____ Hoisting equipment
_____ Belt conveyor
_____ Aggregate production equipment
_____ Subbase compaction equipment
_____ Trenching equipment
_____ Pumps (keep excavation free from water)
_____ Scaffolding
_____ Transportation equipment
_____ Boots & gloves, kneepads
_____ Power tools for form work
_____ Handtools for forming
_____ Sledge hammers
_____ Picks
_____ Hand levels (4 ft, 2 ft, etc.)
_____ Pliers
_____ Rules (6 ft)
_____ Wrecking bars
_____ Pry bars
_____ Wheelbarrow
_____ Pointing or cleaning requirements
_____ Grinding tools
_____ Field office requirements

REINFORCING BARS

_____ Folding rules (6 ft)
_____ Leather gloves and jackknife
_____ Side-cutting pliers (7 in.)
_____ Tape measure (50 ft)
_____ Boltcutter (24 in.)
_____ Hoisting equipment as required
_____ Clawhammer
_____ Oxyacetylene cutting equipment
_____ Portable shear
_____ Portable bender
_____ Hickey
_____ Set of blocks 3/4 inch manila line
_____ Snatch block (for hand hoisting)
_____ Tie wire
_____ Transportation equipment

PLASTER

_____ Hoisting equipment
_____ Scaffolding requirements
_____ Trowels
_____ Margin
_____ Pointing
_____ Pipe
_____ Angle
_____ Plaster's
_____ Brushes
_____ Browning
_____ Finish
_____ Tool
_____ Straightedges
_____ Darbies
_____ Hawks
_____ Mixing machine
_____ Wheelbarrow
_____ Mortarboards
_____ Pliers, shears, boltcutters, etc. for metal lath
_____ Handtools for wood lath
_____ Mechanical plastering machine
_____ Material storage requirements
_____ Transportation equipment
_____ Safety equipment, gloves, goggles, etc.
_____ Water hose or pails
_____ Transportation equipment
_____ Expansion bit
_____ Field office requirements
_____ Storage area requirements

PAINT

_____ Brushes
_____ Spray guns
_____ Hoses (air - paint)
_____ Compressor
_____ Scaffolding
_____ Dropcloths
_____ Paintpots
_____ Safety equipment
_____ Goggles
_____ Face mask
_____ Safety mask
_____ Transportation equipment
_____ Hoisting equipment
_____ Putty knives
_____ Paint scrapers
_____ Wire brushes
_____ Dusting brushes

_____ Sanders (hand power)
_____ Storage requirements (tarps, etc.)
_____ Field office requirements
_____ Spare parts for spray equipment
_____ Hose fittings
_____ Paint gun extension
_____ Paint mixer
_____ Wrenches

CARPENTRY

_____ Hammers and handles
_____ Saws, crosscut, rip, keyhole, and compass
_____ Ripping chisels
_____ Wood chisels
_____ Brace and bits
_____ Squares, framing, "T" and combination
_____ Plumb bob
_____ Hand levels
_____ Screwdrivers
_____ Files
_____ Sharpening stones
_____ Wrecking bars
_____ Pliers
_____ Rules (6 ft)
_____ Tapes (50 ft, 100 ft)
_____ Dividers
_____ Hatchets
_____ Nail aprons
_____ Pencils
_____ Hacksaws
_____ Power equipment
_____ Radial arm saw
_____ Table saw
_____ Jointers
_____ Planers
_____ Shapers
_____ Drill press
_____ Grinders
_____ Chain saws
_____ Routers
_____ Portable electrical hand saws
_____ Sanders
_____ Adzes
_____ Sledge hammers
_____ Wrenches
_____ Scaffolding
_____ Hoisting equipment

SHOP

_____ Shear 16 gage capacity
_____ Sheet metal forming machine
_____ Drill press
_____ Electric hand shear
_____ Hand electric drill with twist drills
_____ Handtools per man
_____ Toolbox with:
_____ Combination square (12 in.)
_____ Steel tape (6 ft)
_____ Cold chisel
_____ Center punch
_____ Rivet set (sets)
_____ Hand groovers (set)
_____ Dividers
_____ Scratch awl
_____ Edge scribe
_____ Screwdriver set
_____ Pliers, combination
_____ Files
_____ Punch set (hand)
_____ Snips
_____ Wood mallet
_____ Ballpeen hammer
_____ Setting hammer
_____ Soldering iron
_____ Hand saw
_____ Hacksaw
_____ Vise grip pliers
_____ Transportation equipment (crew - materials)

WELDING

_____ Arc welding machines (accessories with handtools etc.)
_____ Welder for shop can be permanent (electrical drive)
_____ Oxyacetylene welding and cutting outfits
_____ Vise
_____ Anvil
_____ Forge
_____ Grinding wheel (stationary)
_____ Drill press with complete set of drill bits
_____ Electric hand drill with complete set of drill bits
_____ Protective equipment
_____ Gloves (leather gauntlet)
_____ Leather jackets
_____ Leather aprons
_____ Arc welding hoods (with clear and color lens)
_____ Acetylene welding goggles (with clear and color lens)
_____ Face shields (clear for grinding)

TOOLS

_____ Igniters (acetylene torch)
_____ Marking crayon (soapstone)
_____ Wire brush
_____ Chipping hammer
_____ Files of various types and sizes
_____ Screwdrivers
_____ Hacksaw with blades
_____ Square, combination
_____ Square, framing
_____ Square, tri
_____ Cold chisels
_____ Center punch
_____ Crescent wrenches
_____ "C" clamps (various sizes)
_____ Chain hoist

EARTHWORK

_____ Dozers
_____ Scrapers
_____ Graders
_____ Dump trucks
_____ Power shovels
_____ Draglines
_____ Rollers (grid - sheepsfoot, wobble wheel)
_____ Backhoes
_____ Ditcher
_____ Earth auger
_____ Ripper
_____ Roto-Tiller
_____ Cranes
_____ Cargo slings
_____ Snatch blocks
_____ Spare cable
_____ Quarry equipment
_____ Compressor
_____ Rock drills
_____ Rock dumps
_____ Crusher
_____ Lubrication truck (field)
_____ Water truck
_____ Fuel truck
_____ Low bed trailer and tractors
_____ High bed trailers and tractors
_____ Light standards and generators
_____ Spare parts and tires
_____ Air and water hose

_____ Field office equipment
_____ Storage area materials
_____ Transportation equipment
_____ Buses
_____ Stake trucks
_____ Pickups
_____ Jeeps, etc.
_____ Operator's manuals
_____ Repair parts manuals

PAVEMENT WORK

_____ Pavement breaker
_____ Graders
_____ Front end loaders
_____ Dozers
_____ Dump trucks
_____ Aggregate spreader
_____ Steel wheel rollers
_____ Pneumatic tire rollers
_____ Pavement saw
_____ Asphalt plant
_____ Asphalt pavers
_____ Asphalt distributor
_____ Hand tools for asphalt work
_____ Rakes
_____ Shovels
_____ Lutes
_____ Straightedge
_____ Tamper
_____ Cleaning Equipment
_____ Concrete batch plant
_____ Concrete mixers
_____ Transit mix trucks
_____ Concrete mobile
_____ Concrete spreader
_____ Concrete paver
_____ Concrete finisher
_____ Hand tools for concrete work
_____ Square nose shovels
_____ Concrete rakes
_____ Floats
_____ Trowels
_____ Screed board
_____ Cur'ng equipment
_____ Quarry equipment
_____ Crusher
_____ Compressor
_____ Rock drills
_____ Aggregate drying plant
_____ Aggregate washing facilities

_____ Stake trucks
_____ Forklifts
_____ Rollers for compaction
_____ Crane
_____ Repair parts
_____ Field office requirements
_____ Transportation equipment
_____ Storage requirements
_____ Sweeper, street
_____ Water truck
_____ Water and air hose
_____ Hand levels
_____ Miscellaneous hand tools for stake setting
_____ Operators manuals
_____ Repair parts manual

OVERHEAD ELECTRIC LINES

_____ Block and tackle
_____ Climbing gear
_____ Brace and bits
_____ Hammers
_____ Lineman's bag (tool)
_____ Center punches
_____ Pliers, long nose
_____ Pliers, lineman's
_____ Fire pot
_____ Lineman's gloves
_____ Safety strap
_____ Rubber gloves
_____ Wrenches
_____ Knives
_____ Soldering irons
_____ Cold chisel
_____ Blowtorch
_____ Ladle
_____ Pliers, diagonal
_____ Screwdrivers
_____ Toolboxes
_____ Equipment requirements
_____ Storage requirements
_____ Ladders
_____ Goggles
_____ Lighting equipment
_____ Saws, electrical, hand
_____ Chain saws
_____ Line Truck
_____ Shovels
_____ Pole spikes
_____ Auger truck
_____ Rules (6 ft)

_____ Tapes (50 ft, 100 ft)
_____ Rope
_____ Cable reels

INTERIOR WIRING

_____ Pliers, diagonal
_____ Pliers, Lineman's
_____ Pliers, long nose
_____ Rules (6 ft)
_____ Screwdrivers
_____ Linemen's toolbag
_____ Wrenches
_____ Clawhammers
_____ Brace and bits
_____ Auger bits
_____ Key hole and compass saws
_____ Files
_____ Soldering irons
_____ Electrician's knives
_____ Wire tapes
_____ Circuit hickeys
_____ Blowtorch
_____ Fire pot
_____ Ladle
_____ Testing equipment
_____ Multimeters
_____ Ohmmeters
_____ Ground resistance tester
_____ Phase indicators
_____ Ammeters
_____ Cable pullers
_____ Insulation strippers
_____ Splice kits
_____ Hydraulic bender
_____ Mechanical bender
_____ Crosscut saw
_____ Scaffolding materials
_____ Storage requirements
_____ Safety gear
_____ Transportation requirements
_____ Toolboxes
_____ Tool belts

SOIL PIPE AND INTERIOR PLUMBING

_____ Oilcan
_____ Cold chisels
_____ Round nose chisels

_____ Hacksaw blades
_____ Half Round file, bastard, 10 in.
_____ Handle, file
_____ Hacksaw frame, adjustable
_____ Saw nest, key hole and compass
_____ Pliers, slip (8 in.)
_____ Hammer, claw
_____ Hammer, ball 1 1/2 pound
_____ Hammer handle (14 in.)
_____ Wrench, pipe (10 in.)
_____ Wrench, pipe (14 in.)
_____ Wrench, pipe (18 in.)
_____ Scewdrivers
_____ Handle, hammer, machine
_____ Mechanic's toolbox
_____ Level, 2 plumb adjustment (28 in.)
_____ Rule, wood folding (72 in.)
_____ Wire brush
_____ Shear, type "D"
_____ Reamer, pipe burring
_____ Cutter, pipe 4 x 6
_____ Cutter, pipe 1/8 to 2 inches
_____ Dies, hand
_____ Pipe threader with dies
_____ Cutting oil
_____ Stardrills, 1 set

RIGGING

_____ Snatch blocks
_____ Block and Tackle
_____ Slings
_____ Wire rope
_____ Shackles
_____ Hooks
_____ Spreader Bar
_____ Spare cable

BIBLIOGRAPHY

1. American Management Association. The AMA Curriculum in Construction Management. 1988 Short Course Schedule. Saranac Lake NY: American Management Association, undated.

2. Clough, Richard H. Construction Contracting. New York: John Wiley & Sons, 1975.

3. Decker, Capt Jonathan R., Graduate Student. Personal interview, AFIT, Wright-Patterson AFB OH, 1 June 1987.

4. Department of the Air Force. Civil Engineering RED HORSE Squadrons. AFM 93-9. Washington: HQ USAF, April 1983.

5. -----. Programming Civil Engineering Resources. AFR 86-1. Washington: HQ USAF, 26 September 1986.

6. -----. USAF Formal Schools Catalog. AFM 50-5. Washington: HQ USAF, 1 March 1987.

7. Department of the Army. Construction Management. Subcourse Number EN0375, edition 4. Fort Belvoir VA: U.S. Army Engineer School, September 1974

8. -----. Construction Management. TM 5-333. Washington: HQ U.S. Army, February 1972.

9. -----. Construction Planning. Subcourse Number EN0067, Edition 2. Fort Belvoir VA: U.S. Army Engineer School, undated.

10. -----. Engineering School Subcourse Listing. Newport News VA: The Army Institute for Professional Development, U.S. Army Enginer School, 1985.

11. -----. FY88 Training Needs Survey. Huntsville AL: U.S. Army Engineer Division - Huntsville, undated

12. Department of Engineering Professional Development. Continuing Education in Engineering and Technology July 1987 - June 1988. Madison WI: University of Wisconsin-Madison, undated.

13. Department of the Navy. Builder 1 & C. NAVTRA 10649-F. Washington: Naval Training Command, 1973.

14. -----. Joint NCTC Course Catalog. Port Hueneme CA/Gulfport MS: Naval Construction Training Centers, 27 September 1985.

15. -----. Seabee Planner's and Estimator's Handbook. NAVFAC P-405. Alexandria VA: Naval Facilities Engineering Command, April, 1979.

16. Emory, William C. Business Research Methods. Homewood IL: Richard D. Irwin Inc., 1980.

17. Mclean, Senior Chief Keith., Senior Builder Chief, Telephone interview. Naval Construction battalion, Gulfport MS, 14 May 1987.

18. Merritt, Frederick S. Standard Handbook for Civil Engineers (Second Edition). New York: McGraw-Hill Book Company, 1976.

19. Morris, John W. "Construction Management Training," Military Engineer, 78: 511 (November/December 1986).

20. Schmidt, Capt Gregory A., Graduate Student. Personal interview. AFIT, Wright-Patterson AFB OH, 3 June 1987.

21. The Business Roundtable. Construction Labor Motivation. Report A-2. New York: The Business Roundtable, August 1982.

22. -----. First and Second Level Supervisory Training. Report A-4. New York: The Business Roundtable, May, 1982.

23. -----. More Construction for the Money. Summary Report of the Construction Industry Cost Effectiveness Project. New York: The Business Roundtable, January, 1983.

24. -----. Typical Supervisory Training Program for Construction Foreman. Supplementary Material to Report A-4; First and Second Level Supervisory Training. New York: The Business Roundtable, No date.

25. U.S. Dept of Labor. Construction Safety and Health Regulations (Part 1926). Washington: Government Printing Office, June 1974.

26. Warszawski, Abraham. "Construction Management Program," Journal of Construction and Engineering Management, 110: 3 (September 1984).

27. White, Capt Arville E., Graduate Student. Personal interview. AFIT, Wright-Patterson AFB OH, 1 June 1987.

Vita

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He graduated from high school in 1967 and received an A.A.S. degree in Mechanical Technology from Broome Technical Community College in 1969. Upon graduation, he enlisted in the U.S. Air Force and served as an air freight specialist in Vietnam, Thailand, and the Philippines before being discharged in 1974. He received a bachelors degree in Building Design and Construction from Pittsburg State University in 1976. After graduation, he was employed as a construction field engineer for a large midwest engineering/construction firm until he reentered the Air Force in 1979. After receiving his commission, he served as an engineer at Keesler AFB, Mississippi for two years, and as a field engineer assigned to the 819th RED HORSE squadron, RAF Wethersfield, U.K. from 1981 until entering the School of Logistics, Air Force Institute of Technology, in May 1986.

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Abstract

The purpose of this study was to examine the management of construction projects undertaken by United Stated Air Force Rapid Engineering Deployable, Heavy Operational Repair Squadron, Engineer (RED HORSE) squadrons. The study was aimed specifically at the roles and responsibilities of construction managers who supervise construction workers and plan day to day construction activities on the job site. The study had three main objectives: (1) To determine what types of construction manager training programs are currently available within the Department of Defense (DOD), (2) To identify the major tasks and responsibilities associated with RED HORSE construction management, and (3) To develop a RED HORSE construction manager's handbook which will be a useful reference for construction managers.

The study found that no DOD training programs are specifically designed to meet the unique needs of RED HORSE units. However, one in resident Navy program, and two Army correspondence courses are especially applicable to RED HORSE construction management.

The study identified twenty-two construction management tasks that are essential to successful RED HORSE construction management. A RED HORSE Construction Manager's Handbook was developed based on these tasks. The handbook was incorporated into separate chapters of the thesis.